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# THE COMMERCIAL FERTILIZER INDUSTRY IN CANADA

WITH SPECIAL
REFERENCE TO
THE UTILIZATION
OF NATURAL
RESOURCES

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National Development Bureau
Department of the Interior
Ottawa, Canada
1929

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# THE COMMERCIAL FERTILIZER INDUSTRY IN CANADA.

Department of the Interior,
OTTAWA, Canada,
1928.

GEORGIA
15 1957

## PREFACE.

This memorandum is confined to the manufacture of fertilizer as a commercial industry. Taking for granted the beneficial effect of fertilizer on vegetation, it says nothing about the many factors that ensure or minimize the value of plant food. Such conditions become known to a farmer by experience and education, are exhaustively treated in agricultural publications and demonstrated at Experimental Farms.

The aims in view are:-

I. to put before the Canadian public the latest view of experts in world economics, namely, that Commercial Fertilizer must be produced in ever-increasing amount to maintain the present yield and sustain a multiplying population on the limited habitable area of this planet.

2. to show the amount of Commercial Fertilizer which Canada is using, might use, and may contribute to the world demand.

3. to give a summary of the legislation and tariffs that concern the Canadian industry.

Accompanying the memorandum is a "Natural Resources and Industrial Map depicting the Fertilizer Industry, sources of its raw materials and location of its plants."

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SYNOPSIS

Preface Page

Importance of Commercial Fertilizer ..... 1

Need of artificial fertilizers; problems of production, marketing, etc., as discussed at recent European conferences ..... 4

The Commercial Fertilizer industry in relation to the future food supply of the World ..... 12

The relation between cultivated area and population ..... 15

Economics of the fertilizer industry ..... 17

Nitrogen fixation ..... 20

Comparison of nitrogen demand in the United States and in Canada ..... 21

Detailed estimates of the amounts of nitrogen, phosphorus and potash considered desirable in Canadian agriculture ..... 23

Table 1 illustrating the above ..... 25

Comment on Table 1 ..... 26

Canadian consumption of commercial fertilizer in 1918, and in the year ending March 31, 1927 ..... 27

Table II: details for year 1926-1927 ..... 30

Comment on Table II ..... 31

If all farmed land in Canada were to use chemical fertilizer, what would be the bill? Would the cost be profitable? ..... 32

Estimated increase in value of yield of various crops due to application of a commercial fertilizer ..... 34

Status of the fertilizer industry in Canada ..... 36

Concentrated fertilizer ..... 41

Value of fertilizer ingredients in mixed commercial fertilizers ..... 44

Summary of the Fertilizer Acts 1922, 1927 as amended in Bill 72, 1928 ..... 47

Tariffs - Canadian customs tariff ..... 50
United States tariff ..... 51
British West Indies, Africa, Brazil, Japan, China ..... 52

Notes on the map illustrating the Fertilizer Industry ..... 55

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THE IMPORTANCE OF COMMERCIAL FERTILIZER

Food, clothing and explosives are the primary needs of mankind in peace and war.

Without food man cannot live, without clothing of sorts he does not live, without explosives he cannot be master of inert matter or protect himself in war. An isolated few may live on fish or wild life, but man in his present and increasing numbers depends for his existence on the food and clothing produced by agriculture.

Agriculture - the basic industry of mankind - depends more and more on fertilizer.

The most important fertilizer is nitrogen. Nitrogen, however, is needed not only to supply food and clothing but also for the making of explosives. In case of blockade or embargo a nation without nitric acid plants and short of ammonia is at the mercy of an enemy.

The importance, therefore, of a supply of chemical fertilizer, and especially of nitrogen cannot be over estimated.

Commercial or chemical fertilizers are necessary, first, to supplement the amount of manures available from livestock and natural sources, and, secondly, to make good a deficiency of one or more of the necessary chemical elements.

The barnyard manure available is limited by the number of cows, horses and sheep, and such manure, however rich in nitrogen and humus and desirable for the proper cultivation of a farm or garden, is generally deficient in the mineral elements carrying phosphorus or potash. It is also too bulky for economic distribution on larger areas than the neighbourhood of farm buildings and stockyards.

Other sources of natural manures are industrially negligible. Mussel mud on Prince Edward Island, seaweed on the coasts, deposits from tidal flooding in the Bay of Fundy are locally useful; in districts of moderate rainfall perhaps six pounds of nitrogen per acre may be returned to the soil in rain and snow; potash may be saved from wood ashes in a forest clearing, the street sweeping which, when horse traffic abounded, analyzed about 1.30 per cent nitrogen, 1.00 per cent phosphate, and 0.70 per cent potash and were in great demand from truck-growers, are now made nearly worthless by motor droppings; and human excreta, liquid and solid, invaluable to the Asiatic peasant, are, except in rare cases, entirely wasted.

The Rothamsted patent of 1921 for the manufacture of an exact equivalent of barnyard manure from straw and vegetable refuse by chemical treatment is not yet widely known or used in Canada, and the same may be said of "Humogen" or bacterized peat.

The chemical elements entering into the growth of plants may be arranged in three groups:

| (1) | (2) | (3) |
|---|---|---|
| Nitrogen | Hydrogen | Chlorine |
| Phosphorus | Oxygen | Iron |
| Potassium | Carbon | Magnesium |
| | Silicon | Manganese |
| | Calcium | Sodium |
| | | Sulphur |

The three elements in Group 1, are the legs of the tripod on which all agriculture stands. In all soils from which crops are taken a deficiency in any one of these elements should be supplied, for the measure of the crop-producing power of the soil is regulated by the one of these three elements which is there in least amount. Chemical fertilizers are compound substances carrying these elements either separately or in combination and are bought and sold to supply a deficiency in all or any of the three.

The elements in Group 2 are the base on which the tripod rests. They are all essential to vegetable growth, but being constituents in greater or less degrees of every soil in which plants can be grown at all, they are not regarded as commercial fertilizers. An exception is calcium in the form of lime; a deficiency in lime must be made good but its presence in the soil is a condition of growth rather than a plant food in itself.

The elements in Group 3 are usually present in small amounts in a soil, but their specific value to any crop is still a subject of research. Of these manganese and sulphur are commanding special attention.

The tendency of modern civilization is to decrease effort per unit of production, and the scientific use of fertilizer is an aid to this desirable end.

THE NEED OF ARTIFICIAL FERTILIZERS; PROBLEMS OF PRODUCTION, MARKETING, ETC., AS DISCUSSED AT RECENT (EUROPEAN) CONFERENCES.

In May 1928, two conferences were held in Europe in which the world wide fertilizer industry was discussed by well-known specialists. We give a summary of such of the views expressed in papers and debates as have a bearing on the present and future of the industry.

1. At the Nitrogen Conference, attended by the heads of the two great chemical combines, namely, the "Imperial Chemical Industries" and the German 'Interessen Gemeinschaft' (usually called the I.G.), and by delegates from all important countries except Chile the following resolution was passed unanimously:-

> "Those present at the second International Nitrogen Conference, held on the Adriatic on board S.S. Lutzow, are agreed that food, clothing, and other requisites of a growing population can only be provided in sufficient quantity and without risk of a rise in prices if artificial fertilizers are used on an increasingly liberal scale. The growing use of artificial fertilizers, therefore, constitutes one of the most important means of promoting the well-being of humanity. Those present at the conference consider it desirable that the following means should be adopted for the attainment of the end in view:-

I. By the Industry:-

1. Sites for the erection of artificial fertilizer factories to be chosen with a view to production at the lowest possible cost.

2. The fullest use to be made of progress in scientific knowledge and technique in order to improve and cheapen production.

3. Every effort to be made to discover and produce suitable forms of plant foods and carriers capable of satisfying the varying demand of different plants, taking into account the manifold variations in soil and climate. Among known fertilizers, no single one can be regarded as superior to all others under all circumstances.

4. Artificial fertilizers to be delivered to the consumer as directly and as cheaply as possible.

5. The cost to the consumer of all plant foods to be reduced by these means, but not below a level sufficient to maintain the industry in healthy condition, and in a position to continue to secure improvements in its methods of production.

II. II. - By Agriculture:-

1. Consumption of artificial fertilizers to be increased up to the limit, which will give the consumer the maximum economic result.

2. Improved efficiency in utilization of nutrient by the plant to be secured by comprehensive researches into the laws governing plant life.

2. The knowledge obtained by the results of such researches to be diffused by suitable means of education and publicity.

III. By the State:-

I. Organizations for providing consumers with adequate credits for the purchase of artificial fertilizers at low rates to be created and supported.

2. All Governments to give special consideration to the economic position of the farmer."

From the paper read by Lieut-Col.G.P.Pollitt, D.S.O., M.Sc., Ph.D., Director of Brunner Mond & Co., at this Conference we quote this section dealing with the question of local fertilizer factories:-

"The need for large-scale working is to some extent in opposition to the tendency for individual countries to encourage their own manufactures, and a certain amount of give and take is required. In general it is not worth while considering the erection of local factories for the production of, say, fertilizers until there is an assured home market for a sufficient tonnage to justify a separate works and it seems probable that the erection and working of such factories should be supervised by one of the large-scale manufacturers who have an adequate research organization behind them. The preliminary testing of the market, research into the best types of fertilizers for the particular conditions of the country, and the education of the farmer are best carried out by means of imports. As soon as it is clear what is wanted, and how much material can be usefully applied to the soil, the question of a local factory can profitably be considered. But the new processes are so expensive in capital costs that the greatest care should be exercised in deciding on the size of a plant before going in for the large expenditure involved.

"In all industries there is a general tendency for prices to approach the cost of production by the most efficient methods plus a reasonable margin of profit, and it is to the ultimate benefit of consumers that manufacturers should have every facility for reducing their costs to the lowest possible level. This can only be done by large expenditures on research and by intelligent choice of the most suitable points of manufacture for economic delivery."

"In conclusion, I should like to say that, of the recent advances in chemical technology by far the most important appears to me to be the greatly increased production of fertilizers. The following quotation is taken from Starky's reminiscences recently published:- "The great matter for the world is the tilling of the soil, and it is the peasant that truly represents the race. Assuming the world's population to be 1,800,000,-000, the tillers of the soil probably represent 1,400,-000,000 and it is they who constitute the world."

"The moral of this is clear. The whole world is interested in food, all of us as consumers and by far the most of us in production as well, and the stimulus given to agriculture by the production of cheap and abundant fertilizers, and perhaps even more by the intensive study of the needs of the soil which this production has brought about, is bound to have an enormous effect on the world's principal occupation." (Chemistry & Industry, pp. 532-534).

Apropos of the above it is interesting to recall the following passage from an address of J.C. McLennan, Ph.D., F.R.G.S., Prof. of Physics, University of Toronto, Nov.27, 1927:-

> "It will be possible too with the large supplies of oxygen, hydrogen, nitrogen and phosphorus that we can secure by the use of our spare electric power to build up immense industries for the production of artificial fertilizers, and these products can be used in ever increasing amounts to enrich our grass lands to increase our hay and root crops and to increase - yes, double at least in many places - the production of our grain fields".

The foregoing paragraph was quoted in the House of Commons (Hansard Feb.7, 1928) by a member who adds -

> "We (in P.E.I.) have been growing our potato crop on artificial fertilizers. We have used considerable quantities of them, buying them on the markets of the World, but chiefly from Baltimore, U.S.A. Last year we used about 50,000 tons of mixed fertilizers for the production of our crop. The amount in use has been increasing from year to year and if fertilizers can be produced as here indicated from the waste energy of our electric power and the raw products of Canada can take the place of what we are now importing, it will certainly be a step in the right direction. By providing fertilizers for our people from our own natural resources, it will improve conditions in Canada generally as well as help our trade balance."

In the course of this Conference it was pointed out that the estimated consumption of fixed nitrogen (mainly synthetic) in 1927-8 was 1,400,000 tons or 700,000 tons more than in 1913-14 and that there had been a steady fall in the price of nitrogenous fertilizers and a gradual rise in the price of agricultural products. As there was likely to be an increased production of 2,500,000 tons in the next 3 years, the question arose "Would the world absorb it?" Calculation showed that 92% of the increase could be absorbed by Europe alone if it were applied to the main crops at the rate of 0.8 cwt. per acre, that American consumption was expected to increase by 60%, and that the Far East presented an enormous potential field. It was argued on the other hand that the additional world population in 1928-31 would only consume $\frac{1}{4}$ of the extra food produced by the use of the additional nitrogen in Europe.

- . -

Sir Alfred Mond (now Lord Melchett), President of Imperial Chemical Industries, said that but for the increased food supply made possible by the nitrogen industry the growth of population would have had to be restricted voluntarily or by disastrous crises. The cheap prices made possible by the synthetic industry would greatly help to raise the standard of living in Eastern countries where the most primitive methods of agriculture were still nearly universal.

(Chemistry & Industry, June 1928, p.575-577).

2. At the 'Chemical Industry Conference' held in London in May, 1928, Sir A.Mond said that he had just returned from a conference with nitrogen experts.

They had been considering the problem of feeding the teeming millions of the world. He would say that the most important thing to mankind at the moment was cheap nitrogen. It was true that nitrogen was not the only fertilizer required but the chemical industry was in a position to offer complete fertilizers for all purposes in which the three essentials of nitrogen, potash and phosphates could be mingled in an almost infinite variety of ways.

(Chemistry & Industry, May 18, 1928, p.528).

At the first Annual meeting of 'Imperial Chemical Industries Ltd.' Sir A.Mond spoke to the same effect:- "It is no exaggeration to say that but for the production of synthetic fertilizers, the world would to-day be suffering from a famine."

The research and investigation carried out by the nitrogen organization was of the utmost importance to agriculture.

('Statist.' - June 2, 1928).

A far seeing paper read at this Conference was that by Sir John Russell, D.Sc., F.R.S., the Director since 1912 of the famous Rothamsted Experimental Station founded 85 years ago by Sir J.C. Lawes.

The intention, he said, already being carried out at Rothamsted, is to counteract by intensive research and experiment the element of chance that militates against the profitable use of chemical fertilizer due to conditions of soil and weather caprice; and ultimately to construct. "Tables of Expectancy of Crop Yield".

If such tables prove trustworthy, fertilizer companies having adequate capital will use them as a basis and be able safely to "insure farmers using recognized fertilizer mixtures against getting less than an agreed yield per acre", just as, analogously, the fundamentals of Life Insurance business are based on acturial tables of risk and probabilities.

The present bar to a greater increase in sales of commercial fertilizer is the attitude of the average small farmer, who naturally is hard to persuade that his outlay will not be money lost. Though the odds are at least 10 to 1 that he will not lose, his margin of capital is generally too narrow to accept even that risk.

Now, if the agent could say "You must either win or come out even, if any company shoulders all your risk except you suicidally destroy your crop", would any farmer having any credit or capital fail to buy?

Considering the immensely increased sales that would result, a powerful fertilizer combine could well take chances of a long drought or locusts just as the big Life Insurance Societies accept with equanimity an epidemic of 'flu' or smallpox' but draw the line at suicides.

Sir John Russell fully admitted that in the use of chemical fertilizer there was "always a considerable and uncalculable element of chance" due to soil treatment, time of application and especially the vagaries of the season ... "Over a series of years 1 cwt. of sulphate of ammonia per acre gives an additional 20 cwt. of potatoes, 5 bushels of wheat, 6 of barley, 7 or 8 of oats with little variation from year to year. There is, however, one important exception. When a crop is sown late, the expected increase in yield may not be obtained; indeed, in extreme cases, there may be even a decrease in the amount of grain. Potassic fertilizers and phosphates, on the other hand, show marked difference in effectiveness from season to season, being specially valuable in certain weather conditions, - a property of great value as it holds out hopes of enabling farmers to mitigate the effects of bad seasons."

The purpose of the new work thus sketched by Sir John Russell is to reduce all such variations to order if not to law.

With this in view four important lines of investigation are now being followed up:-

(1) the effect of seasonal conditions on the effectiveness of fertilizers.

(2) the relation between the quantity of fertilizer and the yield of crop.

(3) the effect of variations in time of application of the fertilizer.

(4) the influence of the fertilizer on the composition of the crop.

These investigations are being carried out under new methods which, using a foundation of statistics accumulated for half a century and adopting a new system of precaution to avoid error, give results of higher statistical value in a space of one year than those before obtainable.

The conclusions are being recorded at Rothamsted in diagramatical charts by means of which the complex problems can be readily studied.

THE COMMERCIAL FERTILIZER INDUSTRY IN RELATION TO THE FUTURE FOOD SUPPLY OF THE WORLD.

At the meeting of the British Association for the Advancement of Science (1926) the topic of the law of diminishing returns from the land relative to the increase of population - a topic which has intrigued the economist since Malthus in 1798 threw this fundamental theory into the ring and still more since Crookes' dismal forecast in 1908 - was again discussed.

Whichever side has the better of the argument cycles of time alone can prove, but the manufacturer at any rate is on safe ground, for pessimist and optimist alike look upon a vast expansion of his business as necessary.

The pessimistic view of an ultimate failure or deficiency in the world's food supply is founded on the following statements which, on the basis of existing conditions, are generally accepted:-

(1) that the present annual increment in the white population is about 5,000,000, which necessitates the taking into cultivation a further area of 12,000,000 acres a year.

(2) that the population of China, India and Japan and some other regions have reached their limit, and that the balance between their food supply and maintenance is adjusted only by famine, pestilence and warfare, three agencies whose effects are rapidly diminishing, especially in India and Japan.

(3) that the vast increase in the number of white people in the last century was made possible only by the unoccupied land available for cultivation in the Western Hemisphere and Australia, and that at any rate, the cultivable area of the earth being a fixed amount, it must in time fail to meet the needs of population increasing in geometrical progression.

(4) that the soil is being depleted, and that a very large amount of the fertilizer that might help to counteract the depletion is used to produce cotton and other non-edible substances.

To meet this line of argument, difficult if not impossible to disprove and demanding very serious consideration by the world-mind, which continues to function though its units in their generation die, the optimists put forward arguments that seem to be equal to the emergency for a very long time to come, though not as fundamental as the Malthusian dogma.

They are such as these:-

(1) The area of cultivable land as yet unworked is vastly greater than the pessimists maintain, nor is account taken of the limitless food supply offered by ocean, lake and river.

(2) Voluntary restriction of population is general among many white races and will increase as the standard of living rises. It may however be admitted that this argument is partly balanced by the lessening death rate among children.

(3) Transportation development, especially by the air, is now able to convey food products to any part of the inhabited globe.

(4) The yield per acre can be greatly increased by intensive cultivation, scientific practice, and use of improved machinery. The complaint is that there is over-production of food staples...

(5) The use of chemical fertilizer can be trusted to double the supply of food.

(6) The manufacture of nitrogen from the atmosphere (dating only from 1901) and of the other chemical fertilizers by further electro-chemical invention will be able to supply fertilizer in unlimited amount.

(7) New varieties of food will be discovered by the plant breeder.

(8) Should other supplies fail, sustenance for the human being will be obtained by synthetic chemistry.

THE RELATION BETWEEN CULTIVATED AREA AND POPULATION

This was the title of the address by Sir Daniel Hall, K.C.B., F.R.S., as President of the Agricultural section of the British Association at Oxford in 1926. The address was analyzed and commented upon in the Canadian Monthly Bulletin of Agricultural Statistics for October, 1926 (p.311).

The following paragraphs present the case as it now appears to stand:

Increased production of cheap food precedes an increase of population or is a concomitant.

This is the general law, though population is also somewhat increasing owing to modern prevention and cure of disease, closer attention to child welfare, and we hope by the banning of war. These secondary causes of increase are somewhat counteracted in turn by the attractions of city life, distaste for the hard work of the farm, greater expenditure on luxuries or conveniences unknown till lately, and by consequent birth control.

Cheaper supplies of food are the result either of an extension of the cultivated area or of intensification of agriculture on the area already cultivated.

First, as to the extension of the cultivated area. It is estimated that an average of from 2 to 2, acres of agricultural land are required to supply the needs of one unit of white population living up to the standard of white people, though in the case of Denmark the average is 1.82 acres.

With some 240 million acres of new agricultural land still available in Canada alone, and an unkown potentiality of areas in Russia and other countries, it may be said that any scarcity of a cheap food supply

for the world is impossible for a long time to come, and that the export of food products from under-populated countries will supply any deficiency in those where there is pressure of population.

At the same time it is well to remember that the natural fertility of the soil is being slowly depleted. "Pressure is sooner or later inevitable, and one of the biggest problems before the world at present is to prevent the pressure developing suddenly or becoming unbearable."

Secondly: Apart from an extension of the cultivated area, the sole constant source of cheap food supply is an increase of production from the area already cultivated. This may be effected, as now in certain countries of Europe and in an increasing number of parts of the western hemisphere, by mixed farming, improved methods of agriculture, cultivation of better seed varieties, plants and stocks, but more than in any other way by the use of artificial fertilizers. The trouble lies, as compared with the extension of agricultural area, in the cost. "There is an immense potentiality in the direction of intensified agriculture, but owing to the cost of intensification the extension of the cultivated area affords a cheaper means of increasing total production .... The increase of yield through the employment of fertilizers is considered the most promising direction that improvement can take."

"By the introduction of artificial fertilizers between 1840 and 1870 the average wheat yield of Great Britain was increased by some 10 bushels per acre. The revolution now being brought about by processes of nitrogen fixation now being developed on a vast scale in all civilized countries will result in an almost un-

limited increase in the amount of nitrogen fertilizers available at low prices, compared with the prices of agricultural produce. Here at least is the opportunity for another step up in production from cultivated land comparable with the increase due to introducing artificial fertilizers in Europe in the middle of the last century."

ECONOMICS OF THE FERTILIZER INDUSTRY

The above outline of the views of economic experts will have proved to the manufacturer of commercial fertilizer that his industry is of vast importance to the food supply of the world and has boundless scope.

Fertilizing, however, like charity, begins at home. The manufacturer who reads some of the following pages cannot fail to see that his home market also has boundless scope, that fertilizer applied in Canada in accordance with expert advice would enormously increase the profits of Canadian agriculture and that what he at present supplies is a drop in the bucket compared with the need.

Before presenting the statements that bear out this contention, a few words may be said on fertilizer economics and what is being done and should be done to speed the demand.

An economic policy relating to commercial fertilizers might be based on two premisses:- viz., that all fertilizer produced in any country should be used in that country until its own needs are amply supplied, and conversely, that export of fertilizer, other things equal, is detrimental to a country except as an equivalent for imports of fertilizer material not a domestic product.

If these premisses are admitted, it follows that all fertilizers even when compounded should be admitted free of duty, and that all machinery and supplies not domestically obtainable used in the manufacture of fertilizer should also be admitted free. This is the policy which has been adopted in Canada for the last few years seemingly with benefit both to the industry and the consumer and is indigenous in Britain. A tariff on fertilizer even if "for revenue purposes only" is like taxing a loaf of bread.

An industry to be flourishing, however, depends on a demand for its products. In the case of many manufactured articles a demand is artificially stimulated by advertising, display and appeal to the "herd instinct" and may have no definite bearing on the national well-being, but for no country is it easy to imagine a point of saturation in the case of fertilizer. In this case the national interest requires an increasing demand; depending, as it must, not on fashion or visible merit, but on experience and scientific knowledge of farm economics, the demand has to be fostered and stimulated by the slow process of education.

The price too must be tempting, for in itself a sack of stuff, often malodorous and which is a debit long before the cash comes in, is not appealing; a rule-of-thumb husbandman passes it by and even a scientific farmer shies at paying a price at all exceeding the analysed value.

It is therefore clear that to promote a growing demand for this national necessity there are two requisites, first, an educational campaign and trustworthy advertising, secondly, manufacturing foresight content to offer first rate goods at the least possible margin of profit.

In Canada a great deal is being done to educate the farmer to the need and value of commercial fertilizer and the proper care of farm manure, by the publications of Dominion and Provincial Departments of Agriculture, experimental and demonstration farms, by discussion at Farmers Clubs and in a slight but increasing degree by teaching in the schools. The Agricultural Colleges are of course foci of up-to-date training in this line of science. Also, by the Fertilizer Acts and Regulations of recent years governing the sale of fertilizers, the farmer is ensured against spending good money on diluted goods or paying freight on a super-abundance of 'filler.'

In spite of these influences the spread of knowledge of soils and their demands is slow. The domestic fertilizer industry is comparatively undeveloped and needs coherence. A great deal of tankage and fish offal leaves the country, which though used more than before for hog and poultry feed might be more largely used by the fertilizer industry. The recovery of fertilizer from the sewage of large cities is neglected or has not reached the economic stage as it has in Milwaukee and other places. The production of sulphate of ammonia from ammonia liquor might be increased if it could be sent to central collecting and treating plants. Only at very few Canadian cities is this raw material now utilized.

As the interest of the fertilizer manufacturer is equally the interest of the nation, the policy of the industry should be close co-operation and also the utilization at home of raw material now either wasted or exported. By co-operation the overhead costs of the trade are lessened, prices are stabilized and the ability to advertise

on a large scale is possible only to an industry having abundant capital or income. The example of a country where 200 competitive firms co-operate in a National Fertilizer Association and a campaign has been organized to educate 50,000 farmers in the proper use of fertilizer might be serviceable.

The Canadian Trade Commissioner in New York, June 27, 1928, writes thus:- "While Canadian exporters of fertilizer should benefit by the educative policy of this association, the industry is rapidly becoming so highly organized that quick and strenuous action is imperative. Fertilizer is duty free, and the dearth of some necessary elements in the soil of the United States will undoubtedly keep this product on the free list, but the proposed campaign of national advertising and personal service advocated by the National Association will do a great deal to exclude the marketing of the finished product by foreign manufacturers" -

NITROGEN FIXATION

Under present conditions it is unlikely that Canada will draw to any considerable extent on her great reserves of water power, coal, lignite and lime for the manufacture of fixed nitrogen other than cyanamide. The production of synthetic ammonia has assumed such vast proportions in Europe that competition would be as yet uneconomic, even if there were much demand for the imported product. The essentials for economic production of synthetic ammonia are cheap fuel or water power, large scale operation, ample capital, skilled workers and suitable location of plant. Even

then the profit will be small. It should be noted further that owing to constant discovery of better processes operating plants face the difficulty of extremely rapid obsolescence. Thus it seems advisable to mark time before adopting any large scale system of nitrogen fixation and be content with the certainty that our resources can amply supply any amount of nitrogen in case of need.

The National Research Council of Canada published in 1924 their Bulletin No.II on 'Nitrogen Fixation' and keep an up-to-date record of the latest developments relating to this very important subject.

"It would appear" says 'Progress of Applied Chemistry' 1927, p.174, "that the synthetic ammonia industry must inevitably develop until it attains an importance equal to that of coal, steel, ship-building, etc."

## COMPARISON OF NITROGEN SUPPLY AND DEMAND IN THE UNITED STATES AND IN CANADA.

A United States senate document (No.88,68th congress, pp.13 and 57) states that about 9 million metric tons of nitrogen are removed yearly from the soil of that country by 'agricultural activities' and that the nitrogen returned to the soil from all sources is about 5½ millions, of which commercial fertilizer supplies 216,000 tons. The 'Statistical Abstract' of the U.S.A. for 1926 gives the figures for farm land in crops and in pasture at 391,460,000 acres and 407,000,000 respectively, a total of about 800,000,000. The acreage of Canada cultivated for field crops, pasturage, fruits, tobacco,

etc., is roughly 75,000,000 acres (Canada Year Book, 1926, p. 217.....). This figure is 9.375 per cent of the figure for the United States. Assuming that farming conditions are more or less similar, the figures as applied to Canada for amount of nitrogen removed, amounts returned from various sources and for the yearly deficiency will be, therefore, 9.375 per cent of the figures for the U.S.A. as in the following table:

| | United States' totals | Canada's totals |
|---|---|---|
| | tons | tons |
| Nitrogen removed yearly..... | 9,000,000 | 843,750 |
| Returned by manure..... | 1,750,000 | 164,062.5 |
| " " legumes..... | 1,750,000 | 164,062.5 |
| " " non-symbiotic bacteria.... | 1,000,000 | 93,750.5 |
| " " rain and snow..... | 750,000 | 70,312.5 |
| " " commercial fertilizers..... | 216,000 | 20,250 |
| | 5,466,000 | 512,438 |
| Deficiency ..... | 3,534,000 | 331,312 |
| | 9,000,000 | 843,750 |

The Canadian figure 20,250 tons is relative only, for in fact Canada's return in 1925 is estimated at only 7,471 tons and in 1926 at 12,286, i.e., 68.2 per cent of the U.S. return. The lower figure for Canada is explained partly by our larger comparative amount of new fertile prairie soil, by the larger area in the U.S.A. devoted to crops that make heavy demands on fertilizers such as cotton, tobacco, corn and fruits and also by the severe and protracted Canadian winter which for the conservation of soil fertility is "an agricultural asset of no small value." (Dom. Chemists'address to Com.of Conservation, 1917). It may be noted that the figure of 9 million tons of nitrogen withdrawn

yearly from United States soil implies a draft of 22½ pounds per acre. Bulletin No.8 of the Dominion Experimental Farms shows that a 20 bushel crop of wheat removes 24 pounds of nitrogen per acre and a 200 bushel crop of potatoes 42 pounds. The crop from the 600,000 acres usually farmed for potatoes in Canada could therefore consume all the nitrogen in all the commercial fertilizer now used.

The conclusion drawn from what has been said is that the fertilizer industry in relation to the production and distribution of nitrogen has a boundless field.

DETAILED ESTIMATES OF THE AMOUNTS OF NITROGEN, PHOSPHORUS AND POTASH CONSIDERED DESIRABLE IN CANADIAN AGRICULTURE.

The figures relating to the nitrogen supply in the United States were worked out during the war when 'Nitrogen Situation' was a vital question. The problem then was what amount of nitrogen was available for explosives and what could be spared for agricultural needs. Owing to the very large amount of phosphate rock in the United States and the supplies of potash from native sources being dependent only on development, the question of the phosphorus and potash supplies was not urgent. Since, however, in Canada the production of phosphate from domestic sources is small and that of potash negligible, it is important to ascertain the amounts of these fertilizer ingredients needed for Canadian agriculture and to see how far the average imports and production go to make good any deficiency. It will also be well to see whether the estimated Canadian deficiency of 351,000 metric tons of nitrogen cannot be greatly

reduced by a consideration of actual crops. For it should not be left out of sight that the agricultural conditions of the vast area of the United States may be quite different to those of Canada, and that the reasoning from analogy may be quite misleading.

"We might estimate that cropping results in an annual loss of the soil of 33 pounds of nitrogen, 14 pounds of phosphoric acid and 33 pounds of potash." (Dept. of Agriculture, Bulletin No.3). The field crops on 26,000,000 acres would thus make a draft on the soil of 847,000 metric tons of nitrogen, 406,000 of phosphoric acid and 847,000 tons of potash. If we assume that two-thirds of this draft are replaced by manure and by means other than commercial fertilizer, there is still a loss of 319,000 tons of nitrogen, 135,000 of phosphoric acid and 319,000 of potash. Such figures however hardly offer a practical estimate of the food requirements of Canada's crops, which are largely affected by such factors as crop-rotation, cultivation, humus, quality of soil and the amount of virgin soil. A less theoretical method of finding out what amount of commercial fertilizer is needed to save a gradual depletion may be to give in Table I the acreage of each field crop separately; secondly, the number of pounds of chemicals suggested by the Department of Agriculture as advisable for each crop per acre under normal conditions, with the proviso that such chemicals are not substitutes for manure, clover, etc., but merely supplementary to their use.

To bring the figures of the requisite commercial fertilizers further within practical limits the calculation below (Table I) omits,

(1) the acreage of all field crops, except sugar beet in Alberta, grown in the so-called 'inexhaustible' soils of the three prairie provinces.

(2) the 9,365,000 acres under pasture in Canada.

(3) green vegetable crops including tomatoes, onions, cabbages, sweet corn, green peas, the total acreage of which crops was 30,309 acres in 1921.

TABLE I

| | Crop | Acreage (1925) | lbs. per acre N | $P_2O_5$ | $K_2O$ | Amount in metric tons. N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|---|---|---|
| (1) | Wheat | 1,030,142 | 15.5 | 24 | 25 | 6,480 | 10,033 | 10,415 |
| | Oats | 5,281,086 | " | " | " | 33,221 | 51,439 | 53,582 |
| | Barley | 583,521 | " | " | " | 3,670 | 5,683 | 5,717 |
| | Rye | 119,821 | " | " | " | 749 | 1,167 | 1,175 |
| | Corn | 238,767 | 18 | 48 | 50 | 779 | 4,651 | 4,845 |
| | Fodder Corn | 474,899 | 18 | 48 | 50 | 3,469 | 9,251 | 9,636 |
| | Potatoes | 439,541 | 40 | 48 | 75 | 7,135 | 8,156 | 13,378 |
| | Turnips | 186,213 | 23 | 72 | 25 | 1,332 | 5,441 | 1,889 |
| | Sugar beets | 42,418 | 31 | 48 | 50 | 583 | 822 | 820 |
| (2) | Hay, Clover, Alfalfa | 9,548,577 | 23 | 32 | 25 | 85,071 | 124,007 | 9,688 |
| | Flaxseed | 12,480 | 25 | 30 | 50 | 126 | 157 | 253 |
| | Tobacco | 27,815 | 35 | 42 | 70 | 395 | 474 | 790 |
| (3) | Orchards | 297,053 | 45 | -- | -- | 5,425 | --- | --- |
| | Small fruits and grapes | 24,831 | 31 | 48 | 65 | 312 | 480 | 625 |
| | | 18,307,164 | | | | | | |
| | Totals | 18,307,164 | | | | 148,747 | 221,761 | 112,813 |

(1) Average lbs. of chemicals for all 4 cereals.
(2) Pounds of chemicals advised for hay.
(3) Phosphate & potash omitted as 'seldom profitable in an apple orchard.'

## COMMENT ON TABLE I

The estimate given on page 14 of the amount of the fertilizer that might be profitably used on all the farmed land of Canada is true in theory, but under present conditions of abundant undepleted land occupied by a scanty population is of no practical value except as pointing to the immense field open in time for the fertilizer industry.

Coming down to more solid ground let us consider the greatly diminished bill presented by the figures in Table I. The money cost of the chemical fertilizers in this Table would be:-

| | |
|---|---|
| Nitrogen - 148,747 metric tons at $4.20 a unit..... | $ 76,967,647 |
| Phosphoric acid - 221,761 metric tons at $1.75 a unit..... | 47,811,671 |
| Potash - 112,813 metric tons at $1.20 a unit..... | 16,678,273 |
| Total cost .... | $141,457,591 |

This amount spent on 18,307,164 acres would be at the rate of $7.72 an acre, which though less than the $13.00 spent in Holland, is more than the $4.17 spent in Germany. Since it is improbable that more than ten per cent of the eighteen million acres under consideration is treated with commercial fertilizer in accordance with expert advice, and taking into consideration also the present natural fertility of Canadian soils, we will cut the 141 millions to less than a tenth and say that $14,000,000 value is all that is likely to be absorbed under present conditions.

CANADIAN CONSUMPTION OF COMMERCIAL FERTILIZER

IN 1918, AND IN YEAR ENDING MARCH 31,1927.

Let us try to discover what the actual outlay in Canada has been in recent years. "A rough estimate of the consumption of fertilizers in Canada" was made in 1918. The figure was obtained by "adding the values of the fertilizers and material which may be used directly as fertilizers made in all industries and the value of all such commodities imported and deducting therefrom the sum of the values of similar products exported." Allowance was made for the diversion to other industries of such materials as might otherwise have been used as fertilizer. The result obtained showed that the value of the commercial fertilizer used in Canada in 1918 was $4,408,330. This figure shows an expenditure of $0.08 on the fifty-one million acres of farm crops in 1918, or, omitting the area in the prairie provinces of $0.21 on the remaining twenty-one million acres. On the 18,307,164 acres with which we are concerned in this study the expenditure would be $0.24.

The Census of Canada for 1921 showed that the average amount spent on fertilizer, exclusive of that produced on the farm, was $10.05 for every 100 acres of improved land, the figure varying from $160.30 in New Brunswick and $120.35 in Nova Scotia to $0.22 in Saskatchewan and an average of $0.38 in the three prairie provinces. The total acreage of improved land in 1920 was 70,769,[illegible] acres.

Taking the cost of mixed and separate commercial fertilizer at $43 a ton, the number of pounds used per acre would be 4.6 lbs. The American Fertilizer Review (Dec.1927) estimated the amount of fertilizer used on "all the acres farmed" in the U.S.A. to be 6½ pounds per acre and compared this with 647 pounds used in Holland, 513 in Belgium, 200 in Germany and 50 in Italy.

On the 18,307,164 acres here considered the pounds used in 1918 would be about 11 pounds and in 1926 about 15.

Table II below gives an estimate in detail of the expenditure on commercial fertilizer for the year ending March 31, 1927. The total expenditure works out at $5,903,453 or $0.322 on 18,307,164 acres. Comparing our fertilizer bill per acre with $13.00 spent by Holland, $10.50 by Belgium, $4.17 by Germany and $1.05 by Italy, the inference is that there is no end in sight to the amount of commercial fertilizer that the agriculturist in Canada could profitably use. Unfortunately for the industry "the great majority of agriculturists with the exception of those technically trained and a comparatively few others are not at present in the markets to secure products of this kind." The ordinary farmer prefers to see his auto wheels go round and collect insurance if they fail rather than to see a fertilizer bill and wait for cash results when the crop is harvested and sold. However, the gradual depletion of the soil and the spread of agricultural science is on the side of fertilizer business and for these

among other reasons "the development of large fertilizer industries appears to offer one of the best opportunities in Canada for extensive industrial expansion in a direction where there is promise of a large home market as well as a possible export market" (Bulletin of the Department of Mines, No. 825, 1924.)

The economic aspect of an export market for fertilizer will be considered later; it is enough now to say that the home market could profitably consume many times the amount that this home industry now produces and to export more than a million dollars worth of usable manufactured fertilizer and raw material looks like selling a cow's milk to the creamery before her calf has sucked its fill.

Note. - Since the figures in Table II were compiled for the fiscal year ending March 31, 1927, the Dominion Bureau of Statistics has issued a report covering the year ending June 30, 1927. The statistics there given fully corroborate the figures summed up in Table II. Valuing the fertilizer tonnage sold domestically at the prices prevailing in the first week of July, 1927, the expenditure on the same acreage to which we have applied the figures in Table II was $0.343 per acre, and shows the slight upward tendency noted. The exports, taking the tonnage at the above values, amounted (after deducting cyanamide) to $1,242,154 inclusive of fish offal and other raw material.

| Table II Year 1926 Item. | A Production | B Imports | C Used in Fertilizer Industry | D Used in other Industries | E Exports | F For use in Canadian Agriculture | Remarks (A+B) - (C+D+E) = F. |
|---|---|---|---|---|---|---|---|
| | $ | $ | $ | $ | $ | $ | |
| Ammonium Sulphate | 1,015,978 | 135,455 | 71,148 | 54 | 813,155 | 267,676 | |
| Ammonia Liquor | 10,939 | | 10,939 | | | | |
| Ammonium Phosphate | | 10,550 | 5,614 | 4,936 | | | |
| Cyanamide | 3,962,509 | 3,961 | 14,938 | | 3,823,628 | 127,904 | |
| Basic Slag | 75,051 | 74,820 | 5,259 | | | 144,612 | |
| Super-phosphate | | 925,515 | 93,275 | | | 832,240 | |
| Phosphate Rock | 43,941 | 69,808 | 112,466 | | 833 | | |
| Bones, crude, ash, meal, flour char. | 187,171 | 194,509 | 20,221 | 157,110 | 80,502 | 123,847 | |
| Tankage | 660,178 | | 82,533 | ? | 577,645 | | |
| Dried blood | 18,309 | | 18,309 | | | | |
| Sodium Nitrate | | 1,417,710 | 65,484 | | | 1,352,226 | |
| Potash | | 470,814 | 107,090 | | 5,916 | 357,808 | |
| Wood Ashes | 16,609 | | 4,112 | | 12,497 | | |
| Fish and Whale Guano | 213,136 | | | | 213,136 | | |
| Fish scrap | 1,500 | | 1,500 | | | | |
| " offal | 247,715 | 7,058 | | ? | 254,773 | | |
| (Complete fertilizer) | | | | | | | |
| a. Meat Industry | 807,678 | | | | | 807,678 | |
| b. Fertilizer Industry. | 1,235,415 | | | | 27,503 | 1,207,912 | |
| c. Animal Oil Ind. | 15,346 | | | | | 15,346 | |
| d. Imported | | 666,204 | | | | 666,204 | |
| Other Material | 203,965 | 108 | 204,073 | | | | |
| Totals | 8,715,590 | 3,976,512 | 816,961 | 162,100 | 5,809,588 | 5,903,453 | |

Notes: (1) Where an item used is not separately listed in official statistics of production, production figures are here set down as equal to the amount used, e.g. Dried blood, fish scrap, ammonia liquor, (2) Where it is impossible to say what part of the production or imports is used in other industries e.g. Feed for swine and poultry, the fertilizer industry is credited with this e.g. bone, tankage, fish offal.

COMMENT ON TABLE II

(1) The export of raw material in the shape of tankage, fish offal and crude bone amounting to not far from $1,000,000 a year should be seriously considered from the points of view both of the fertilizer industry and of the needs of the soil. In the absence of demand for commercial fertilizer in certain areas and having regard to long distance haul either to a factory or thence to a consuming centre, it may well be more profitable to export these raw materials for treatment across the border, and for the user to import treated material, but a more wide spread demand should enable factories in Canada situated at strategic points to utilize profitably all the raw material available.

(2) The large export of ammonium sulphate also calls for comment. The surplus from Sydney, Nova Scotia, can probably be sold to better advantage in the West Indies owing to low freight by water than at inland centres of demand subject to railroad rates Nevertheless, the further use of domestic ammonium sulphate in place of a large part of imported Chile nitrate of soda might well be fostered both as a saving to the grower and as a benefit to the domestic industry seeing that the 1928 price in Ontario of sulphate of ammonia analysing 20% nitrogen is $55 a ton compared with $57 for 15.5 per nitrate of soda.

(3) The heavy import of superphosphate is due to the lack of sedimentary phosphate rock in Canada. The discovery of the deposits in Florida and other parts of the United States killed the economic production from Canadian crystalline apatite. In spite of our large production of sulphuric acid it is more economical to import superphosphate than to carry American rock for treatment at home. Should the deposits of sedimentary phosphate in British Columbia prove important in extent and in phosphorus content, the West may be independent of imports of superphosphate.

(4) The imports of potash are a necessity; in the absence of some unexpected discovery, we must always be dependent on European potash salts or Nebraska brines, for the potential output of potash from our sugar beet waste, wood ashes, feldspar, cement factories and kelp is negligible.

(5) Viewing the table as a whole, the most striking feature is the very small volume of fertilizer production and use of fertilizer products, whether domestic or imported.

It is most important in the national interest to speed the development of an industry, which, if the demand for fertilizer were at all in proportion to the need, could, as we have shown, be expanded ten, twenty or a hundred fold. The domestic demand, to say nothing of the foreign, will inevitably increase as population grows and the fertility of the soil is depleted, but its increase should not be left to the slow pressure of natural law. The less distant hope both for the benefit of agriculture and of the fertilizer industry lies in the rapid dissemination of a scientific knowledge of agriculture among farmers, orchardists and truck growers of Canada and in a vigorous publicity campaign to demonstrate that the proper use of nitrogen, phosphorous, potash and lime swells a bank account.

## IF ALL FARMED LAND IN CANADA WERE TO USE CHEMICAL FERTILIZER, WHAT WOULD BE THE BILL? WOULD THE COST BE PROFITABLE?

It is astonishing to see what the total fertilizer bill for Canada might be if we included the field crop acreage of the three prairie provinces, amounting in 1925 to 35,673,260 acres, in the area that some day may require commercial fertilizer according to the amount suggested by the Department of Agriculture for farmland under normal conditions. We should find that the further amount of metric tons of each chemical ingredient required would be:

| | | |
|---|---|---|
| Nitrogen | 222,440 | metric tons |
| Phosphoric acid | 347,466 | " " |
| Potash | 361,964 | " " |

Adding these figures to the totals given in Table I for the six older provinces, the totals for all Canadian farming land would be:

| | | | | | |
|---|---|---|---|---|---|
| Nitrogen | 148,747 | + 222,440 | = 371,187 | metric | tons |
| Phosphoric acid | 221,761 | + 347,466 | = 569,227 | " | " |
| Potash | 112,813 | + 361,964 | = 474,777 | " | " |

The cost would be:-

| | | | |
|---|---|---|---|
| Nitrogen | at $4.20 a unit (1%) | = | $192,067,001 |
| Phosphoric acid | at $1.75 " " | = | 122,725,341 |
| Potash | at $1.20 " " | = | 70,111,031 |
| | Total cost | | $384,983,373 |

Though this expenditure, which is about 23 per cent of the gross agricultural revenue of Canada for 1925, ($1,690,966,000) is at first sight appalling, consideration suggests that after all such an expenditure when the time is ripe might be profitable.

Figures below show that the increased value of 5 crops only; viz.: wheat, oats, barley, rye and potatoes might be expected to amount to $355,000,000. This sum would wipe off 92 per cent of the expenditure and the remaining 8 per cent, if spent on all the other crops, including fruit, grown in Canada at $1.87 an acre on the remaining 16 million acres, would at a low estimate yield an average increase of 10 per cent in value over similar crops to which no commercial fertilizer had been applied.

The value of such crops in 1927 was $325,000,000 the profit by increase would thus be $32,500,000, which sum would wipe out the remaining $30,000,000 of the total fertilizer bill and leave a profit of $2,500,000.

The indirect value of more intensive agriculture in relation to dairy, beef, sheep, hog and poultry industries as exemplified in countries where large amounts of commercial fertilizer are used in an extra asset of high value.

ESTIMATED INCREASE IN VALUE OF YIELD OF VARIOUS CROPS DUE TO APPLICATION OF A COMMERCIAL FERTILIZER.

(1) Wheat (5 year average yield in

| | | |
|---|---|---|
| Netherlands | 41.9 | bushels. |
| England | 33.3 | " |
| Sweden | 30.1 | " |
| Germany | 27.3 | " |
| Canada | 16.8) | " |

If the yield in Canada were increased by 10 bushels per acre on 22,000,000 acres the profit at a 3-year average price of $1.07 a bushel would be - ..... $ 235,400,000.

(2) Oats (5 year average yield in

| | | |
|---|---|---|
| Netherlands | 51.9 | bushels. |
| England | 44.5 | " |
| Germany | 41.5 | " |
| Sweden | 39.2 | " |
| Canada | 32.0) | " |

If the yield in Canada were increased by 10 bushels per acre on an average of 15,000,000 acres, the profit at a 3-year average price of 46 cents would be ..... $ 69,000,000.

(3) Barley (5 year average yield in

| | | |
|---|---|---|
| Netherlands | 51.9 | bushels |
| Germany | 34.5 | " |
| England | 33.8 | " |
| Sweden | 31.6 | " |
| Canada | 26.2) | " |

If the yield in Canada were increased by 7 bushels per acre on a 5-year average acreage of 3,130,000 acres, the profit at a 3-year average price of 56 cents a bushel would be..... $ 12,269,000.

(4) Rye (5 year average yield in

| | | |
|---|---|---|
| Netherlands | 32.3 | bushels. |
| Sweden | 26.2 | " |
| Germany | 23.8 | " |
| Canada | 14.6) | " |

If the yield in Canada were increased by 10 bushels an acre on an average acreage of 1,400,000 acres, the profit at a 3-year average price of [illegible] cents would be ..... $ 10,500,000.

(b) Potatoes 3 year average yield in

| | | |
|---|---|---|
| Netherlands | 212 | bushels. |
| England | 193 | " |
| Norway | 192 | " |
| Germany | 162 | " |
| Canada | 125) | " |

If the yield in Canada were increased by 50 bushels per acre on a 5-year average acreage of 611,000 acres, the profit at a 3-year average price of [illegible]1 cents a bushels would be..... $ 27,800,000.

Total increase $354,969,000.

Note:

The United States Fertilizer Review, January 1929, said that owing to various factors concerning which there were insufficient data, an exact estimate of the increased yield of crops that was obtained by farmers by the use of commercial fertilizers was practically impossible, but, judging from a fairly comprehensive study published in 1925 covering the 1923 season, the value of the increased yield obtained by the use of fertilizer was from $650,000,000 to $700,000,000 in 1926.

A paper on "Economics of Fertilizer Use" in the Journal of the American Society of Agronomy (Vol.17, 1925, pp.198-210) was prepared by Sidney B.Haskell, then Director of the Massachusetts Experimental Station and now Vice-president of the Synthetic Nitrogen Products Corporation of New York City. Though working with data

that he characterized as "woefully deficient" and considering only a limited number of crops, he estimated the increased value added to these crops by the use of fertilizer in 1923 to be $697,644,000. The amount used in 1923 is estimated by the National Fertilizer Association at 6,444,764 tons and in 1926 7,600,000 tons at an average cost of $32.85 a ton.

THE STATUS OF THE FERTILIZER INDUSTRY IN CANADA

The fertilizer industry has, since April 10,1924 been freed from the last vestiges of a tariff by customs items 663 and 663 b, admitting free entry to "articles entering into the cost of the manufacture of fertilizers" and to "fertilizers compounded or manufactured.

The effect of the change both on the prices paid by the consumer and on the prosperity of the industry is an interesting subject for the economist.

To get at the facts from the consumer's viewpoint we can take those grades of mixed fertilizers whose prices are recorded in a particular month of 1923 and onwards, and similarly the price of superphosphate which was the only specific commodity affected by tariff by amendment at the date in question. Before April, 1924, fertilizers compounded or manufactured were subject to tariff duties of from 5 to 10 per cent.

To get at the facts from the manufacturer's viewpoint we may take the number of firms operating, the capital used and wages paid, and the amount of production in the years 1923 to 1926 inclusive. We must also take into consideration the production of fertilizer by industries other than the fertilizer industry proper.

In comparing the prices paid by the consumer in 1923-4 and in 1928 and the prosperity or the reverse of the industry in the same years, certain factors must be taken into account. In the first case the prices of mixed fertilizer, superphosphate, ammonium sulphate, basic slag, etc., are affected by the world market for goods carrying similar chemicals, such as phosphate rock, nitrate of soda, Belgian slag, etc., and also by varying rates caused by seasonal demand. In the second case the number of operating firms may have been affected by mergers carried out during the period in question.

Allowing for these possible causes of error the following tables are of interest:-

Table I. Price of fertilizers to consumers.

" 2. Status of the fertilizer industry proper.

" 3. Total production of complete fertilizer.

" 4. Consumption in Canada.

Table I. Comparative average wholesale cost of fertilizers in November, 1923, 1924 and November, 1925 - 6,7,8, (July) to Farmers' Club and Dealers, freight paid.

| Mixed Brands | | Ontario (Toronto) | Maritimes (Halifax) | Decrease or increase of price since 1924. |
|---|---|---|---|---|
| 2 N - 8 P - 10 K | 1923-4 | $41.87 | $40.40 | Ont. - 3.12 |
| " " " | 1925-8 | 38.75 | 38.65 | Mar. - 1.85 |
| 4 N - 8 P - 4 K | 1923-4 | 43.00 | 41.00 | Ont. - 2.57 |
| | 1925-8 | 40.73 | 38.73 | Mar. - 2.27 |
| Ammonium Sulphate (21%) | 1923-4 | 83.00 | 76.00 | Ont. - 11.50 |
| | 1925-8 | 71.50 | 63.89 | Mar. - 12.11 |
| Superphosphate (16%) | 1923-4 | 22.00 | 20.50 | Ont. + 1.09 |
| | 1925-8 | 23.09 | 19.28 | Mar. - 1.22 |
| Basic Slag (16%) | 1923-4 | 25.00 | 22.00 | Ont. - 5.34 |
| | 1925-8 | 19.66 | 18.28 | Mar. - 3.72 |

Note:

The above commodities were those alone in which tariff charges in Canada could have effect on price. The inference to be drawn from the figures given in table 1 (which are taken from Vols. I to V of "Seed, Feed and Fertilizer Markets" published by the Dominion Department of Agriculture) is that, except in the isolated case of superphosphate in Ontario, the consumer has benefitted by the removal of duties.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nitrate of Soda | 1923-4 | $67.50 | 61.75 | | Ont. | + $0.11 |
| (15.5% N) | 1925-8 | 67.61 | 60.72 | | Mar. | - 1.03 |
| Dried Blood | | 86.50 | 78.00 | 1924 | Ont. | - 6.22 |
| (12% N) | | 80.28 | 80.12 | only) | Mar. | + 2.12 |
| Bone Meal | 1923-4 | 50.00 | 43.50 | | Ont. | - 6.44 |
| (3 N 21 P) | 1925-8 | 43.56 | 42.42 | | Mar. | - 1.08 |
| Potash (Muriate) | 1923-4 | 41.38 | 36.88 | 1924 | Ont. | + 7.85 |
| (50%, 48 & 48½) | 1925-8 | 49.23 | 42.03 | only) | Mar. | + 5.15 |

Note:

The above 4 commodities were not subject to any tariff charges, all having been on the free list. No inferences therefore can be drawn from the changes in prices as to the benefit or the reverse to consumer or manufacturer.

Table 2 - Status of the Fertilizer Industry (proper) in 1923, 1924, 1925, 1926.

| | 1923 | 1924 | 1925 | 1926 | Increase or decrease (1923)(1926) |
|---|---|---|---|---|---|
| Firms Operating | 18 | 14 | 13 | 12 | - 6% |
| Capital Employed | $3,616,001 | $2,072,488 | $2,095,608 | $1,891,054 | -47.7% |
| Employees | 329 | 166 | 201 | 221 | -32.8% |
| Production value | | | | | |
| (a) complete fertilizer | 1,113,857 | 1,086,806 | 1,142,510 | 1,235,415 | +10.9% |
| (b) bone flour and meal | 9,773 | 8,840 | 9,322 | 8,075 | -17.3% |
| (c) fish scrap, basic slag, poultry and stock feeds, wheat pickle, tankage, superphosphate, etc. | 363,614 | 181,499 | 285,955 | 206,099 | -43.3% |
| Production totals | $1,487,244 | $1,277,148 | $1,437,787 | $1,449,589 | - 2.5% |

Note :

It will be seen from the above table that, comparing 1926 with 1923, though the firms operating were less by 6 (owing possibly to mergers) and though the capital employed was less by nearly 50% and the employees were fewer by more than 30 , the production value of the specific complete mixed fertilizer which comprised 75% and 85% of the whole production increased by nearly 11%. It can also be seen by table 3 below that the production value of complete fertilizer in Canada including that by industries other than the fertilizer industry proper increased by 66.87%.

Table 3 - total production of complete fertilizer.

| | 1923 | 1924 | 1925 | 1926 |
|---|---|---|---|---|
| (a) production by fertilizer industry proper. | 1,113,857 | 1,086,806 | 1,142,510 | 1,235,415 |
| (b) by other industries | 252,486 | 452,197 | 520,619 | 807,678 |
| Totals - | 1,366,343 | 1,539,003 | 1,663,129 | 2,043,093 |

Increase of production of complete fertilizer by all industries in 1926 compared with 1923 - 66.87%.

CONSUMPTION TABLES 1923, 1924, 1925, 1926.

Consumption for any year is estimated by deducting the exports from the sum of production and imports.

Table 4 (all fertilizers)

| | 1923 | 1924 (transition year from April 10) | 1925 | 1926 |
|---|---|---|---|---|
| Production of all fertilizers | | | | |
| (a) in fertilizer industry | 1,487,244 | 1,277,145 | 1,437,787 | 1,449,589 |
| (b) other industries | 2,639,506 | 2,117,973 | 2,338,306 | 2,787,465 |
| Imports | 2,051,975 | 1,838,853 | 2,387,970 | 3,419,624 |
| | 6,178,725 | 5,233,971 | 6,164,063 | 7,656,678 |
| Exports | 996,237 | 1,346,618 | 735,356 | 980,518 |
| Total consumption | 5,182,488 | 3,887,353 | 5,428,707 | 6,676,160 |

Increase in 1926 above that in 1923 = 28.82%.

| Table 5 | 1923 | 1924 | 1925 | 1926 |
|---|---|---|---|---|
| Production of complete fertilizer | | | | |
| (a) in fertilizer industry | 1,113,857 | 1,086,806 | 1,142,510 | 1,235,418 |
| (b) in other industries | 252,486 | 452,197 | 520,619 | 807,678 |
| Imports | 331,558 | 486,268 | 418,379 | 539,690 |
| | 1,697,901 | 2,025,271 | 2,081,508 | 2,582,786 |
| Exports | 341,338 | 274,860 | 186,465 | 102,827 |
| Total consumption of complete fertilizer. | $1,356,563 | $1,750,411 | $1,895,043 | $2,479,856 |

Increase in consumption of complete fertilizer in 1926 above that in 1923, 82.87%.

Note:

In the above tables the production and exports of cyanamide have been purposely omitted for, though produced in Canada, it has been very nearly all exported for use by the American Cyanamide Company, operating in the United States.

(b) The year 1924 cannot properly be taken into account for comparison with other years, for the duty on manufactured fertilizer was removed on April 11, 1924. A comparison of 1923 with either 1925 or 1926 or both is more free of variables.

Summarising the facts revealed by the tables it may be said that, since free trade in manufactured fertilizer was provided by legislation -

(1) the price to the consumer has fallen considerably.

(2) the manufacturer of a special product--compound fertilizer--has increased his output at a greatly decreased cost of capital and labour.

(3) the production of complete fertilizer by other industries has increased to a still greater extent.

(4) the increased production of fertilizers has been concurrent with the increasing demand from Canadian agriculture.

(5) the value of imports has greatly increased and the value of exports has greatly diminished.

Note on Exports and Imports

Increase of imports of fertilizer and decrease of exports are both advantageous to national agriculture. The only benefit due to export of fertilizer lies in exchange for foreign products. On general principles this is desirable, but in this particular case it is less so, because the use of the exported fertilizer to the benefit of increased agricultural production at home is foregone. If, however, any fertilizer is produced domestically for which there is at present little or no market at home (e.g. cyanamid in Canada) or if production of a particular fertilizer in a district where export is easy and the distance from the main point of consumption at home makes the substitution of an imported fertilizer more economical, export is the best means of disposal. Imports of fertilizer whether manufactured or raw are always a real benefit to a nation. Imports of manufactured complete fertilizer are a benefit to the farmer as a safeguard against a rise of price. Nevertheless, the domestic manufacture of complete fertilizer from our own raw materials should be developed in the interest of the soil and on the general principle of retaining the cost of manufacture in Canada when possible.

CONCENTRATED FERTILIZER

In Canada where the four or five districts specializing in fruit growing are widely separated and where intensive farming is limited to the few thickly populated districts and high priced land, the manufacturer

of fertilizers who aims at other than a local market must produce a compound containing as little make-weight as possible. Even without the addition of a filler, a ton of highly concentrated plant food necessarily contains a large proportion of carrier. This policy is the more necessary for two reasons, first, the growing custom of farmers' cooperative societies and individual farmers to buy the raw materials and do their own mixing, and secondly, the remarkable results obtained by the I.G. or German Chemical combine. Following on an enormous production of fixed atmospheric nitrogen and its utilization in the manufacture of sulphate of ammonia, urea and potassium nitrate, the combine is now manufacturing complete fertilizers, highly concentrated and free from filler by the combination of atmospheric nitrogen with potash and phosphoric acid. The future, if not the present competition of this gigantic concern, which is closely connected with similar industries in the chief countries in Europe and the United States, has to be taken into account seriously by the manufacturer of fertilizers. In 1928-9 the capacity of the I.G. plants operating at Merseburg and Oppau is estimated at 700,000 metric tons of synthetic nitrogen, derived from 770 million cubic metres of air, and the forecast production of fertilizer salts of all kinds during the same period is 3½ million tons.

The following quotations from Chemical and Metallurgical Engineering, June, 1928, may well be noted:

> "Fertilizer manufacture in Germany under the direction of the I.G. has developed into a chemical industry of the first magnitude based on fundamental principles of science and engineering. A new technology has been developed that

is unlike anything the fertilizer industry has known before. The products are almost chemically pure plant foods in concentrated form that can be mixed in suitable proportions to meet the needs of various soils and crops, and from their initial manufacture to their experimental application the whole business is conducted with scientific care and accuracy. In its manufacturing aspects particularly the industry offers marked contrast to the empirical methods that have hitherto characterized the fertilizer business ....."

"But the I.G. does not stop with the manufacture of fertilizers; it extends its interest to their experimented application and for this purpose maintains near Oppau an agricultural experiment station. Here scientific studies are made on the effect of various fertilizers on different soils and crops to determine the most favourable conditions for large yields of food stuffs. Tests are made first in pots, second in 1 - sq. met. plots, third in small field areas and finally on large farms. The practical results of interest to German agriculture are published in a monthly magazine distributed free to farmers and other interested persons. A score of offices for advice and consultation are maintained in different parts of Germany and every effort is made not only to ascertain the practical requirements of the farmer, but also to transmit to him the results of scientific experimentation. In this respect the I.G. is following the traditional methods of its dye business, fully realizing that success in synthetic fertilizer manufacture must rest finally on the degree to which the products meet the needs of agriculture."

The fertilizers produced comprise ammonium sulphate (in the absence of native sulphur this element is obtained from gypsum), urea, ammonium phosphate, nitrates of calcium, potassium and ammonium, and also complete fertilizers to suit all conditions.

On pages 30-42 of Bulletin No. 92 of the Dominion Department of Agriculture important varieties of commercial fertilizer, their analyses, etc., are fully described. The concentrated fertilizer urea ('Floranid') contain 46.6% nitrogen; ammonium sulphate nitrate ('Leuna saltpeter') 26% soluble N; 'Ammo-phos' either

16.45% N. and 20% Ph. acid or 10.7 N. and 48% Ph. acid according to grades; 'double' and 'treble' superphosphate contain respectively about 28% or 45% available phosphoric acid.

An important compound fertilizer now on the market is Nitrophos-ka produced by the I.G. in Germany at the rate of 10,000 tons a month. The two grades of this compound analyse respectively nitrogen 17% or 14.7%; $P_2O_5$ 11.7% or 10.2% and $K_2O$ 21.1% or 25.6%.

Another concentrate is Nitro-chalk made by Imperial Chemical Industries from Ammonium nitrate and dried calcium carbonate obtained as a waste product in the manufacture of ammonium sulphate from ammonium carbonate and gypsum. (Prog. of Applied Chem. 1927, page 12).

VALUE OF FERTILIZING INGREDIENTS
IN MIXED COMMERCIAL FERTILIZERS.

There are two methods by which a farmer can easily test the market value of a given brand of fertilizer:

(a) by finding the market value of the 'unit' (the trade name for 1% of the special chemical in the 2,000 pound ton) of nitrogen (N) phosphoric acid (P) (available) and potash (K).

or (b) by finding the value per pound of these plant foods in the ton.

To simplify the illustration of these methods, we will assume that the 'carriers' of the plant food are simply sulphate of ammonia for nitrogen, superphosphate for phosphoric acid and potassium muriate for potash, and not combinations of other varieties of carriers such as tankage, fish meal, bone meal, etc.

The tag formula in each case is 5 - 8 - 7 (N. P. K) percentage in the ton.

The wholesale prices in Ontario for July 1928 were:

| | | |
|---|---|---|
| Sulphate of ammonia | (20% N) | $55.00 a ton |
| Superphosphate | (16% P) | 20.00 " " |
| Potassium Muriate | (50% K) | 55.00 " " |

(a) Unit Value:

Divide the price per ton of the carrier by the percentage:

Nitrogen - $\frac{\$55.00}{20}$ = $2.75 per unit

Phos. acid - $\frac{\$20.00}{16}$ = $1.25 " "

Potash - $\frac{\$55.00}{50}$ = $1.10 " "

Multiply these unit prices by the percentages stated on the tag:

N. $2.75 x 5 = $13.75
P. $1.25 x 8 = $10.00
K. $1.10 x 7 = $ 7.70

Total market value of plant food. $31.45

(b) Value per pound:

Divide the price per ton of the carrier by the number of pounds it contains in the ton and multiply by the actual amounts of chemical contained in the ton.

N. $\frac{\$55.00}{400}$ = $13.75 per lb. x 100 N. = $13.75

P. $\frac{\$20.00}{320}$ = $ .625 " " x 160 P. = $10.00

K. $\frac{\$55.00}{1000}$ = . .55 " " x 140 K. = $ 7.70

Total value of plant food - $31.45

Comparison of values of same analysis (5-8-7) on same date (July, 1928) and same composition in Ontario, British Columbia, and Nova Scotia according to prices at same date.

| | Ont. | B. C. | N. S. |
|---|---|---|---|
| Sulphate of Ammonia | $55.00 | $70.00 | $54.00 |
| Superphosphate | $20.00 | $22.00 | $18.00 |
| Potassium muriate | $55.00 | $52.00 | $43.20 |
| Mixed fertilizers (5-8-7) | $45.30 | -- | $35.90 |
| Value of plant food | $31.45 | $35.78 | $28.60 |
| Manufacturers and jobbers margin (wholesale) | $13.85 | -- | $ 7.30 |

After working out values by one of the above methods a farmer can determine whether the margin between the value of the plant food and the wholesale cost of a mixed fertilizer is wide enough to make it worth while to mix the ingredients himself according to the instruction given on pages 43-47 of Dept. of Agriculture. Bulletin No. 92.

Filler

Since in the above example it would require 800 pounds of sulphate of ammonia to supply 5% of N. to the ton, 1,000 pounds of superphosphate to supply 8% of P. and 280 pounds of muriate to supply 7% K. the ton requires 220 pounds of 'filler' to complete its weight. The filler may be dry sand, fine loam, powdered peat or gypsum or lime, though this last should not be used in a mixed fertilizer containing potash salts.

As these fillers have no fertilizing value the freight paid on them is lost. Thus highly concentrated fertilizers, if mixed to suit the crop, are of better value than those of a low grade, e.g. a 2-8-2 mixed fertilizer selling at $28.32 in Ontario and composed of the same materials as above, has a plant food value of only $17.78 and requires filler amounting to 710 pounds.

SUMMARY OF THE FERTILIZER ACTS 1922, 1927

AS AMENDED IN BILL 72, 1928.

Registration of Brand

Sec. 4, Subs. 1.

"No person shall manufacture, import or advertise any fertilizer for sale in Canada, unless each brand is first registered with the minister and a registration number assigned to it."

Subsec. 2. Registration fee.

$10, $20, $30 for each brand according as it contains one two or three of nitrogen, phosphoric acid and potash."

Subsec. 3 & 4.

A registration number authorizes sale until the first of July following: may be renewed at original fees.

Sec. 4 - Non resident applicant.

Subsec. (8) "If the applicant for a registration number be non-resident in Canada, the application shall be signed by a representative or agent in Canada of the applicant as well as by the applicant himself, and shall contain an undertaking by the agent or such representative to be held responsible for due compliance with the provisions of this Act."

Sec. 5.- Brand and analysis

(1) No person shall sell, offer, expose or hold for sale in Canada any fertilizer unless each package or tag durably attached thereto is marked with the following information only:

(a) Name and address of manufacturer or importer.

(b) Brand name.

(c) Registration number and year of issue.

(a) guaranteed analysis stating separately in minimum percentages only, without fractions and whenever present in the fertilizer.

(i) water soluble nitrogen.

(ii) total nitrogen.

(iii) available phosphoric acid.

(iv) total phosphoric acid.

(v) potash soluble in water.

(vi) in the case of basic slag or natural rock phosphate or a mixture of both, the fineness thereof.

(vii) whenever present in the fertilizer, the percentage by weight of leather, hoof, horn, hair, wool-waste, peat, garbage, tankage or any similar organic material unless it has been treated in such a way as to make the nitrogen or potash or phosphoric acid therein available as determined by methods of analysis to be prescribed by regulation.

Subs. (2) If sold in bulk, above information shall be stated on the invoice of sale

Sec. 6.

"No person shall advertise, offer, sell, expose or hold in possession for sale in Canada,

(a) any fertilizer except as provided by regulation, unless it contains not less than 2% of nitrogen or five per cent of available phosphoric acid, or two per cent of potash soluble in water, and not less than a total of 14% of nitrogen, available phosphoric acid and potash soluble in water or

(b) any substance or material claimed to possess properties beneficial to soil fertility or plant growth unless such claims are substantiated by experimental

"which acceptable to the Minister."

Sec. "

"No person shall advertise, offer, sell, expose or hold in possession for sale any potash salts containing more than 5/10 of 1% of anhydrous borax or mixed fertilizer containing more than 1/10 of 1% anhydrous borax, or any fertilizer containing sufficient destructive ingredients or properties which may prove harmful to plant growth when the fertilizer is used in a reasonable manner."

Sec. 8

"This Act shall not apply to any selling or offering for sale of fertilizers for manufacturing purposes."

Sec. 9

Section 4 of this Act shall not apply,-

(a) "to fertilizers manufactured from a prescription received by the manufacturer from a purchaser in the purchaser's own handwriting and countersigned by an inspector appointed under this Act, provided that such fertilizers are not purchased for re-sale or actually again sold in Canada."

(b) to the following fertilizing substances when sold in their commercially pure state, not mixed with any other material and containing of plant food ..... and possessing fineness not less than the percentages stated hereunder, namely:-

Nitrate of soda ..... 15% N.
Sulphate of ammonia ..... 20% N.
Superphosphate ..... 16% available phosphoric acid.
Basic slag ..... 10% available phosphoric acid and 80% fineness.
Natural rock phosphate ..... 25% total phosphoric acid and 80% fineness.
Sulphate of potash ..... 48% potash soluble in water.
Muriate ..... 48% potash soluble in water.

Sec. 11.

Any purchaser of a fertilizer may obtain an analysis on application to an official analyst by payment of a prescribed fee and subject to regulations regarding the sample.

Sec. 15.

Penalties for violation of the Act or regulations under it vary from $100 to $500 or up to 30 days imprisonment in default of payment of fine.

Sec. 19.

Adulteration, incorrect marking or false representation are violations of the Act.

Note:

The above summary supplies the more important details of the Fertilizer Act now in force, but the full text of the "Act to regulate the sale of Agricultural Fertilizers" should be obtained by those interested in the use, sale, or manufacture of fertilizer.

By the provisions of the Act the farmer is assured that what fertilizer he buys is good standardized plant food, the reliable manufacturer is protected against dishonest or unscientific competition and the quality of Canadian fertilizer is officially guaranteed in foreign markets.

## TARIFFS

CANADIAN CUSTOMS TARIFF, 1928.

| | | |
|---|---|---|
| Item 467a. May 12, 1923. | Machinery, of a class or kind not made in Canada, or the parts thereof for the manufacture of fish meal, stock and poultry feed, and fertilizer from fish and waste thereof ..... ..... | DUTY Free |

| | | |
|---|---|---|
| Item 661 | Fertilizers, unmanufactured, including | |
| June 30, 1926 | phosphate rock, kainite or German potash | |
| | salts and German mineral potash; bone dust, | |
| | charred bone and bone ash; fish offal or | |
| | refuse and animal or vegetable manures ... | free |
| Item 663 | Fertilizers, compounded or manufactured | |
| April 11, 1924 | n.o.p. ..... | free |
| Item 663a | Cyanamid or lime nitrogen ..... | free |
| May 12, 1923 | | |
| Item 663b | Articles which enter into the cost of the | |
| April 11, 1924 | manufacture of fertilizers, when imported | |
| | for use exclusively in the manufacture of | |
| | fertilizers ..... | free |
| Item 372 | Blast furnace slag ..... | free |
| Item 217 | Sulphuric and muriatic acid per 100 pounds | |
| | | $17\frac{1}{2}$, $22\frac{1}{2}$, 25. |
| Item 218 | Acid phosphate, not medicinal ..... | $12\frac{1}{2}$, $17\frac{1}{2}$, 20. |
| Item 552 | Bags or sacks of hemp linen or jute | 15, $17\frac{1}{2}$, 20. |

GOODS SUBJECT TO DRAWBACKS:

| | | |
|---|---|---|
| Item 1046 | Materials used in the manufacture of articles entitled to entry under tariff item 663b when such articles are sold to manufacturers to be used as specified in said item ..... | Drawback 99% |

Note:

Importations under tariff item 467a are subject to the sales tax of 3 per cent on the customs duty paid value in accordance with resolutions effective February 17, 1928. Specifications of machines to be actually imported and particulars as to the exact purpose for which they are to be used must be furnished.

(1929 sales tax 2%)

UNITED STATES TARIFF ITEM
(Fordney Act, 1922)

Par. 1453 "Guano, basic slag, ground or unground, manures and all other substances chiefly used for fertilizer, not specially provided for; provided that no article specified in Title 1 shall be free of duty under thi paragraph", e.g.

Par. 7 - ammonium sulphate $\frac{1}{4}$ of 1 cent per lb.
" 7 - ammonium phosphate $1\frac{1}{2}$ cents per lb.
" 71 - bone black or bone char 20 per cent ad valorem.

Par. 1018 "Bags or sacks made from plain woven fabrics of single jute yarns or from twilled or other fabric composed wholly of jute - 1 cent per pound and 10% ad valorem.

BRITISH WEST INDIES

There are 15 separate tariffs for the various islands, but in none of these are fertilizers, manufactured or not, subject to duty, except possibly in the isolated case of a particular island.

UNION OF SOUTH AFRICA

No. 171,177 Fertilizers in bulk, animal, mineral or vegetable, artificial or natural, phosphate rock..... free

NORTHERN RHODESIA

"All kinds of manures which the collector of customs is satisfied are imported for use as manures ..... free

BRAZIL

Article 2, Section 4, Law No. 2524 (1911) reads, "Natural or artificial fertilizers unfit for any other use, sulphate of ammonia, superphosphate of lime, animal and artificial guano, also fertilizing mixtures

containing potassium, phosphoric acid and nitrogen) shall be admitted free of customs duties and registration tax if imported by agriculturists, syndicates or merchants. Chilian saltpetre will only enjoy this exemption when imported direct by agriculturists for use in cultivating."

In 1924, however, the law imposed a 2 per cent ad valorem c.i.f. general duty on all imports.

JAPAN

Par. 189 Sulphate of ammonia and nitrate of soda
1. refined ..... 20% ad valorem
2. other ..... free
422. Kainite and similar salts ..... free
646. "Manures including oil cakes uneatable, dried fish, bone dust, dried blood, bone ashes, guano, superphosphate of lime, calcium cyanamide, etc." ..... free

CHINA

The Chinese duties are estimated in Haik-wan Taels, i.e. an arbitrary valuation, stated monthly by the Chinese Maritime Customs, regulating the value of the Haik-wan Tawl as compared with the Yan Silver dollar. The H. K. Tael generally equals $1.50 in Chinese Silver currency, i.e. from 65 - 75 cents in American Dollar currency according to price of silver.

The weight of imports is estimated in piculs, (1 picul = 133-1/3 pounds) e.g. nitrate of soda has or had a tariff duty of .1 H.K. Taels per picul.

In the southern provinces (including Shanghai and Tientsin) there is or was a regular general duty on imports of 5 per cent ad valorem plus a surtax of 2½ per ce

Note:

Mr. L.L. Cosgrave, Canadian Trade Commission, (P.O. box 300, Shanghai) in August, 1927, warns merchants

against quoting duties on imports into territory not under national control owing to the constant changes of taxation in these areas.

MAP ILLUSTRATING THE FERTILIZER INDUSTRY

The industrial map accompanying this memorandum has these features:

a) List of all producers in Canada whether of complete mixed fertilizers or of ingredients needed for fertilizer manufacture.

(b) Location of producers by provinces, names of firm or individual producing and the special products of each signified by letters following each name.

(c) The special products are lettered thus:

A - complete mixed.
B - bones including raw, ground, meal, etc.
C - cyanamide.
D - dried blood.
E - ammonium sulphate.
F - fish guano or offal.
G - basic slag.
K - potash
L - lime (crushed)
O - sulphuric acid.
S - super phosphate.
T - tankage.
W - wood ashes.
X - ammo-phosphate.

To make this list as complete as possible circulars were sent to every firm or individual whose names could be found in trade lists, annuals, or magazines as likely to be interested. To those who did not respond a second letter and another circular were addressed in case the first had miscarried or been overlooked. A long interval was then allowed to lapse to await replies before the map was finally drafted.

Should any names have been left out, or any new firms have come into the field, the Natural Resources Intelligence Service will be grateful for the information in case a further edition is demanded.

# THE COMMERCIAL FERTILIZER INDUSTRY IN CANADA

WITH SPECIAL
REFERENCE TO
THE UTILIZATION
OF NATURAL
RESOURCES

PAMPHLET NUMBER TWO

## VEGETABLE WASTE AS A SOURCE OF FERTILIZER

Natural Resources Intelligence Service
Department of the Interior
Ottawa, Canada
1929

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## REFERENCES

"On the decomposition of cellulose by an aerobic organism (spirochaeta cytophaga)", H. B. Hutchinson and J. Clayton, Journal of Agricultural Science, Vol. 9, pp. 143-173, 1927.

"Artificial Farmyard Manure", H.B. Hutchinson, Ph.D., and E. H. Richards, B.Sc., F.I.C., Journal of Minister of Agriculture, Pt. I, pp. 398-411, 1921.

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Report 1923-24, p.31, 'The Micro-organisms of the Soil'.

"Bacteria of the Soil and the Decomposition of Cellulose", P.H.H. Gray, 1925, Rothamsted Technical Paper No. LXXIV.

Agricultural Journal of India, Vol. XXIII, Part II, p.80-85, March 1928.

"Biochemical Decomposition of Cellulosic Materials with special reference to the action of Fungi", R. D. Rege, (Rothamsted) M.Sc. (Bombay) Ph.D. (London). Annals of Applied Biology; Cambridge University Press, Feb. 1927.

"Synthetic Farmyard Manure", E. H. Richards and R. C. Amoore, Harpenden, 1926.

355A/MM

Par.3. Claims that 90 hours of continuous contact between the solution and the carbonaceous material is sufficient to 'load' this fermentable material and make it available as manure; but the specification points out that the loaded material, if left stored under cover or not for three months will lose up to a further 40% of its dry matter (i.e. will be rotted further) and that the insoluble nitrogen content will increase from $\frac{1}{2}$ per cent to 2 or $2\frac{1}{2}$ per cent. In this latter condition it is physically and chemically the same as well rotted farmyard manure.

To maintain a continuous process allowing for continuous contact the supply of carbonaceous material may be periodically renewed.

Par.4. Sums up the purpose of the process. A quotation from the 'specification' describes it more fully.

"The prevent invention is based upon studies which have shown that under appropriate conditions definite reactions may be brought about between carbonaceous matter and nitrogenous solutions, whereby not only can practically the whole of the nitrogen be recovered from these solutions, but the nitrogen so removed is converted into a form which, while insoluble in water, becomes available in presence of soil and is easily assimilable by plants."

Fundamentally the process consists in the utilization by certain aerobic bacteria of both the nitrogen and carbon which they bring together in their own bodies in the form of an insoluble nitrogen derivative. This fixed nitrogen is plant food.

Par.1. 'Soluble' or 'Insoluble' mean soluble or insoluble in water. Soluble ammonium salts, etc., cover ammonium sulphate, ammonium carbonate, sodium nitrate, cyanamide, ammoniacal liquor from gas works, ammonium phosphate, ammonium nitrate, sewage, urine, etc.

'Dilute' means a concentration of soluble nitrogen so low as not to interfere with the proper development of the micro-organism; the high limit of concentration is 100 parts of soluble nitrogen to 100,000 parts of the solution, but wherever possible as in the case of activate wheat straw it is necessary to reduce the concentration to 10 parts in 100,000.

'Aerobic Conditions' mean that air whether free or forced must be allowed access to the operative organisms.

'Carbonaceous Material' includes besides straw all varieties of vegetable refuse dry or green, though those containing an excess of lignin in proportion to pentosans should be discarded.

'Activated carbonaceous material' means that wherein the organisms present have reached a stage of development enabling them to utilize the material for nitrogen fixation.

'Loaded' material means that carbonaceous material which by fermentation has reached its capacity of retaining insoluble nitrogen. Various materials differ in this capacity, e.g. 1,000 parts of dried wheat straw will render insoluble and retain 7-10 parts of soluble nitrogen (equivalent to 35 or 50 parts of a nitrogen compound such as sulphate of ammonia).

Par.2. Implies that all the soluble nitrogen in the compound used except about 10% can be rendered insoluble by use of appropriate amounts of carbonaceous material. There must be no excess of this material beyond its capacity to react (see page 17).

Patent No. 152,387 Accepted October 14, 1920.

The claims of the patent are these:-

I. A process for the recovery in an insoluble form of nitrogen from dilute solutions of soluble nitrogen compounds such for example, as a solution of ammonium salts, sewage and the like, which comprises maintaining the solution in contact under aerobic conditions with actuated carbonaceous material, for example activated straw until the said carbonaceous material is fully loaded with insoluble nitrogen compounds formed from the soluble nitrogen or until the greatly proportion of soluble nitrogen in the solution has been transformed into insoluble compounds.

2. A process as claimed in claim I in which the soluble nitrogen is reduced to 10 per cent or less of the amount present in the original solution.

3. For carrying out the process claimed in claim I activating the carbonaceous material by maintaining it in contact under aerobic conditions with a dilute solution of soluble nitrogen compounds, for example, a solution of ammonium salts, sewage or the like for a sufficient period of time, for example, for not less than 90 hours or more.

4. The herein described process for the recovery in insoluble form of a nitrogen from dilute solutions of soluble nitrogen compounds.

Dated Dec. 15, 1919.

The 'complete specification' attached to the above patent explains the meaning of the terms used and the process by which the resulting manure is obtained.

Taking this specification in conjunction with what has been said earlier in this paper, the following points are to be noted:

The liquid oozing from the fermenting straw is dark brown and has odour. It is probable that it is through this effluent that the small amount of nitrogen is lost.

Synthetic manure is identical in chemical and physical properties with well rotted farmyard manure, except that the latter may contain appreciably more phosphorus and potash derived from the feed of the animals.

Farmyard manure has three constituents, faeces, urine, straw. The faeces contribute only to the physical character of the product, the nitrogen content being mainly inert and contributing little to decomposition. "Despite the facts that the manure heap usually consists of the liquid and solid excrements of different animals fed with widely different diets together with litter of various kinds and in variable proportions, and that this mixture is allowed to mature under conditions absolutely lacking in uniformity, the majority of the available data regarding the composition of farmyard manure indicate a striking similarity in the precentage of fixed or non-ammoniacal nitrogen." A mean of 43 records in England, America and Europe shows 2.09 per cent N. (p.23,par.3). The nitrogen content of both synthetic and farmyard manure is practically constant; that of phosphoric acid and potash is subject to control. An important fact was also recorded in the course of farm-scale operations, namely that synthetic manure does not lose nitrogen on exposire to weather, whereas farmyard manure heaps under similar conditions lose from 10% to 30%.

At this stage of experimental research the practical application of the discovery was handed over to the Agricultural Development Company, though research workers at Rothamsted are still engaged on problems to which the discovery has given rise.

The residual liqour from ammonia recovery plants or gas works, sewage or animal urine are among the carriers of ammonia in soluble form.

(2) Wetting.

The chief obstacle to large scale operations arise from the tardiness with which raw straw takes up the moisture necessary for fermentation. If pits are available this difficulty may be overcome by immersing the straw for 2-4 days, after which the free liquid may be drained off.

(Note:- In dry districts where sloughs or swamps are adjacent to wheat fields, use might perhaps be made of these to obviate the difficulties attending a very dry climate.)

If the straw is stacked on open ground, no advantage seems to be obtained by continual wetting with large quantities of water, but the straw may be saturated by sprinkling with water, and allowing 2 days to elapse before another sprinkling. During this time a slight fermentation with increase in temperature takes place which renders the straw more capable of absorbing another application.

When the interior of the heap is found to be uniformly moist, the nitrogen may be applied in solution, or else cyanamide or another carrier may be broadcasted over the heap and watered in. Local conditions must govern the process to be adopted.

Comparison of Synthetic Manure with Farmyard Manure

Synthetic manure is plastic and almost odourless except for a slight fusty smell.

In colour it is blackish if prepared by a nitrogen compound in the presence of free lime, and dark brown if prepared from soluble alkalies such as ammonium carbonate, liquid ammonia, urea or peptone or in the presence of sodium hydroxide or sodium carbonate.

It was discovered further that not only does over-'loaded' straw lose nitrogen but that under-loaded straw picks up nitrogen by the agency of bacteria until the proper content of nitrogen is reached.

There are therefore 3 phases:

(1) a phase of equilibrium during which the straw supplied with the requisite nitrogen rots without appreciable loss of nitrogen.

(2) a dispersive phase during which the straw over-loaded with nitrogen loses nitrogen until equilibrium is restored.

(3) an accumulative phase during which the straw picks up nitrogen until equilibrium is reached.

It was shown later by R. W. Rege (Annals of Applied Biology, Feb. 1927) that 2 factors control the decomposition of ripe cellulosic material in the presence of assimilable nitrogen, namely the energy or food factor (pentosan) and the inhibitive factor (lignin). Destruction being from outside inwards, lignin prevents the micro-organism from piercing the tissue and obtaining their pentosan food. The ratio of decomposition decreases as the ratio of pentosans to lignin decreases. Wheat straw has a ratio of available pentosans to lignin of 1.04, poplar 0.54, pine 0.12. For easy decomposition the ratio of the energy factor to the inhibitory should be more than 1. It is therefore possible to make an index of the decomposability of carbonaceous materials.

In large scale work several factors have to be taken into account which do not operate in laboratory experiments:-

(1) Commercial carriers of nitrogen.

Urea and ammonium carbonate though the most suitable carriers of nitrogen are too expensive at present for general use.

Cyanamide has been used with success and contains a sufficiency of free lime.

Sulphate of ammonia must be supplemented with fine ground limestone or chalk or waste lime from soap works; fermentation can be induced by the use of $\frac{3}{4}$ cwt. of sulphate of ammonia and 1 cwt. of finely divided carbonate of lime for 1 ton of straw.

Later a new organism was also found by Mr. P.H.H. Gray which not only decomposes cellulose rapidly, but unlike the 'spirochaeta cytophaga' acts in presence of sugar and is even stimulated by small quantities of the xylose and lignin that occur in straw.

At first the most promising results had come from subjecting straw to a culture of 'spirochaeta cytophaga', but it was found that the decomposing effect was due not so much directly to the action of the bacillus but indirectly to the effect of the substances contained in the culture fluid. The required organisms were found to be naturally present on the straw or in the dust and need not be deliberately added by culture.

Attention was then concentrated on the food supply needed for cellulose--decomposing organisms and on the aerobic chemical and temperature conditions necessary for their efficiency.

It was found that if air was excluded there was no change in straw after even six months, but that if under aerobic conditions soluble nitrogen compounds were supplied at an optimum temperature of 35° Cent. (95°F.) rotting proceeded rapidly until about 50 per cent of the dry matter had been lost.

An important fact came to light relating to the supply of soluble nitrogen. It was found that if this was supplied at the rate of 0.72 parts of nitrogen per 100 parts of dry straw all the added nitrogen was converted from a soluble to an insoluble organic form, but that, if the nitrogen compounds were added in excess of a limit, loss of nitrogen took place until the concentration or alkalinity was reduced by volatilization to the necessary limit. The highest concentration for rapid break down of straw is below that of the weakest undiluted urine.

the barn roof to the straw stack has been suggested as an easy means of accomplishing this. Care would have to be taken in any case to avoid leaching the fertilizing constituents out of the stack."

Extract from "Farm Products in Industry" by George M. Rommel, 1928, New York. pp. 186-8.

The steps by which the Rothamsted Experimental Station arrived at the discovery patented in 1920 may be traced by reference to the following papers and are summarised below:-

"On the Decomposition of Cellulose by an Aerobic Organism", H.B. Hutchinson and J. Clayton. Journal of Agricultural Science, 1919, pp.143-173 (Rothamsted Report 1918-20, p.48).

"The Utilization of Straw and the Production of Artificial Farmyard Manure", H.B. Hutchinson and E.H. Richards. Journal of Ministry of Agriculture, 1921. (Roth. Rep. 1918-20, p.57).

"Artificial Farmyard Manure", H.B. Hutchinson and E.H. Richards, Journal of Ministry of Agriculture, August 1921, pp.398-411.

Experiments had been tried at Rothamsted to make a humus-farming manure from straw by bacterial decomposition alone, but though the available starch and pentosan of the carbohydrate material was easily decomposed by the agency of the bacilli, the cellulose and ligno-cellulose were not decomposed; the straw remained tubular and the fertilizing effect on a crop was practically nil.

Soil examination had revealed, however, the presence of a micro-organism capable of breaking down cellulose. This organism had so far eluded notice, but it was now isolated, studied and named 'Spirochaeta Cytophaga'. It was found to require air and soluble nitrogen as food; in the absence of either it ceased activity. This organism attacked cellulose only and was unable to feed on sugar, starch, or any organic acid. The temperature at which it flourished was 30° Cent. (86°Fahr.) but it was killed by exposure to 60° C. (140°F.)

At Rothamsted problems connected with synthetic manure are studied continuously and materials from all over the world go there to be tested as to their availability. The American Adco Company distributes "Detailed Directions for making Artificial Manure by the Adco Process". This two-page leaflet should be read by every grower of agricultural produce.

Here is a recent note on ARTIFICIAL MANURE as used in the United States -

"The farmer does not have to wait for the manufacturer to buy his raw cellulosic material from him in order to put it through a manufacturing process. He can be a manufacturer himself if he finds it practical to use the new methods of converting straw into artificial manure which have recently been developed. This process promises to make matches out of date as the best means of getting rid of our Mid-West straw stacks. As the native fertility and humus of the soils of the Mississippi Valley approach exhaustion, the replacement of these vital necessities for profitable plant production becomes increasingly important.

The process of converting straw stacks into artificial manure is more bacteriological than chemical but requires chemicals in its application. Experiments at the Rothamsted Experiment Station in England led to the development of a process of adding nitrogenous and other chemicals to straw stacks which brought about the rapid decomposition of the straw by alkaline fermentation, and produced manure which gave equally good results as stable manure when applied to crops. The Rothamsted authorities patented the process and the material used, which is called "ADCO," is manufactured and sold under the patent rights. The ADCO process as developed in England required so much hand labor that its adoption in the United States has been hindered, but the merits of the proposition warrant the adaption of the process to American farm conditions.

One of the latest discoveries in soil chemistry is the fact that the micro-organisms which decompose cellulose require the addition of nitrogen before they will act. Dr. E. B. Fred of the Wisconsin Agricultural Experiment Station, who has made extensive experiments with ADCO, informs the writer that he found that the decomposition of straw, when it is used, is materially hastened by using some cheap leguminous hay as a "starter," in addition to the chemicals. Low-grade sweet clover hay, laid down with straw in alternate layers as the stack was built, gave very quick action.

The limiting factor in using such processes on American farms appears to be water, after the labor problem has been met. The stack must be kept wet until it is rotted. In some seasons sufficient rain falls to accomplish this. In most seasons some water will have to be applied artificially. A drain pipe from

It would seem from the experiments in Missouri and India noted above that nitrogen compounds, phosphate of lime, etc., used independently of the perhaps similar ingredients in Adco can be relied upon as effective provided that the factors influencing the process of conversion are the same. It will not be doubted however that it is advisable for a grower not versed in chemistry to use a converting material scientifically compounded and not to trust his own ideas as to how bacteria and amoebae should be fed and multiplied.

The expert farmer or grower can doubtless use any kind of carrier of soluable nitrogen, whether it be cyanamide, sewage or urine, but to avoid the trifling extra cost insuring success by utilizing the exact results of years of research by the most experienced soil chemists and bacteriologists might be hazardous.

1928 Dr. F. M. Lawrence, the U.S.A. agent for the American Adco Company mentioned in 1925, writes:

"The past two years have witnessed an enormous increase in the use of the Adco process in the United States and a growing recognition of its value in Canada. I regret to say, however, that adoption of the method has been mostly by professional gardeners, truck farmers and home gardeners. The great service which Rothamsted had in mind when developing the process, the utilization of straw and similar carbonaceous compounds, remains largely undone; for the western farmer is strongly conservative and slow to adopt new methods." Field Adco is now sold at $80 per ton, making the cost of finished manure about $2.00. Quantity production of the reagent may permit further reduction in price.

A number of agricultural experiment stations in the United States are working with the process, but little has yet been published.

Rothamsted and in extension of their former work" the writers attempted the manufacture of farmyard manure on a considerable scale. The material used was weeds, jungle grass, sugar cane trash and bagasse, refuse straw, etc., treated with dilute cattle urine and washings collected from the cattle sheds on the government farm with the addition of a small amount of bone meal.

Two experiments were made:

(1) With cattle urine diluted 10 times to contain about 0.5 to 0.1 per cent. nitrogen applied to 2,000 lbs. sugar cane trash and dried teak leaves in pits.

(2) With a solution of ammonium acetate to contain 0.5 per cent nitrogen with the addition of a little sodium phosphate.

A quarter lb. (100 c.c.) to 25 lbs. of trash left for four months proved effective. Analysis of the manure thus made gave:

| | Moisture | $Ph_2O_5$ | $K_2O$ | Nitrogen |
|---|---|---|---|---|
| (1) | 68.34 | 0.3806 | 0.462 | 0.319 |
| (2) | 67.82 | 0.206 | 0.2633 | 0.655 |

'First class manure' to the amount of 150 tons was made from material of which most was previously wasted and "for the first time the Dacca farm has an ample supply of farmyard manure". The success at Dacca was repeated on other farms and for some considerable time now all government farms and seri-cultural nurseries in Bengal may have been making their own farmyard manure. Urea or ammonium phosphate may be used in place of ammonium sulphate and bone meal, for laboratory experiments show that this or diluted cow urine or cow dung and water produce the most rapid and satisfactory results.

These experiments are interesting as suggesting that even before Rothamsted had published the scientific basis of their discovery, success had been empirically attained.

1927 'Successful Farming' (U.S.A.) for November (pp.7, 107) had an article by W. A. Albrecht stating that the scheme of farming in America did not admit of the Adco process which was not economically suitable as being too 'laborious' and requiring too much attention to keep the piles moist. The writer described a modified scheme practised on the 1,800 acre farm of E.M. Poirot in Missouri, where "a chemical mixture (mainly ammonium sulphate, superphosphate and Limestone) was fed into a threshing machine through a hopper and a section of a fertilizer distributor set just over the blower and run by a belt from one of the shaker shafts. One hundred and fifty pounds of chemicals were used to each ton of dry straw. The piles were made flat and low (6 ft.) so that the rains were able to start the process, and water if necessary was added later. In 1926 three tons of the manure costing 85 cents a ton for every ton of straw threshed in August was ready to go back on the soil in December. The treatment followed one with superphosphate and lime. The high price of sulphate of ammonia was, he thought, against the general adoption of the process.

1928 The Agricultural Journal of India for March, Vol. xxiii, Part II, p.80-85, illustrated by a cut of the piled stacks, gives an account of the practice adopted for manufacturing manure at Dacca, Bengal, by M. Carberry, M.A., B.Sc., D.S.O., M.C., Agricultural Chemist to the Bengal Government and R. S. Finlow, B.Sc., F.I.C., Director of Agriculture in Bengal.

In this province manure is especially needed owing to the scarcity of cattle dung, the increased use of which by the peasants for fuel is due to the lessening of the jungle areas.

In 1921 some 'Adco' was obtained from the agent in Calcutta and it was seen that "its content of nitrogen and phosphates facilitated the decomposition of organic refuse into valuable manurial material"-----"In view of the valuable practical lead given by

| | Nitrogen | Ph.Acid | Potash |
|---|---|---|---|
| Synthetic Manure | 2.19% | 1.20 | 0.58 |
| Bullock | 2.45 | 1.04 | 2.83 |
| Cow | 2.20 | 0.99 | 2.24 |

1925 The 'Rural New Yorker' June 27 had a notice of Adco and presumed that special bacteria were cultivated and added to the chemical powder--a supposition which as will be seen later was contrary to fact.

1925 The Live Stock Journal (London) for August 28 notes the discovery of a 'new beneficent bacillus' which co-operates with another micro-organism, but neither of which multiply or perform their proper work of decomposition unless specific chemicals and a specific degree of moisture are present. This Journal also records a test in very dry weather on a potato crop in Rhodesia.

The material used for treatment with Adco was mealie stalks cut in 3-inch lengths, green grass and dry grass. The results were:-

with farmyard manure a yield of 14,346 lbs. per acre (234 bu.)

with synthetic manure from maize stalks a yield of . . . . . 13,103 lbs. per acre (218 bu.)

with synthetic manure from green grass a yield of . . . . . 12,153 lbs. per acre (202 bu.)

with synthetic manure from dry grass a yield of . . . . . 9,815 lbs. per acre (163 bu.)

1925 In the Gardeners' Chronicle of America for August (p.216) Dr. F.J. Lawrence stated that Adco was used in the King's garden at Windsor and that some 20 agricultural experimental stations in the U.S.A. besides specialists and individuals were working on the process. He adds "another year will see it in general use".

1925-26 The Rothamsted Report said that the Adco process was at work in 30 countries.

were distinctly promising. A large scale test made with potatoes on an Essex farm showed that straw manure plus commercial fertilizers gave a yield of 10 long tons, 11 cwt. per acre compared with 11 long tons, 17 cwt. from the application of cow manure plus commercial.

1923-24. The Rothamsted Report (p.32) stated that "in the past season no less than 3,000 tons of straw and like material were treated in Britain alone in addition to much larger quantities treated abroad".

1924 The Journal of the Minister of Agriculture (p.1163) published details of a trial on oats on a farm on Romney Marsh, which is interesting as a comparison with the application of bullocks' dung and as a proof that the rotting of the straw is essential.

| | Yield per acre |
|---|---|
| Plot 1. | |
| 15 tons artificial manure in December and commercial at sowing time | 54 bushels |
| Plot 2. | |
| 21 tons bullocks' dung in December | 46 " |
| Plot 3. | |
| 15 tons artificial manure in December: none at sowing time | 50 " |
| Plot 4. | |
| Chaffed straw in December with sulphate of ammonia and chalk at sowing time | 34 " |

1925 The 'American Fertilizer' of January 24th contained an article by Dr. F.M. Lawrence who represents the American Adco company at 1740 Ludlow Street, Philadelphia. In this he gives an admirable and succinct account of the nature of the discovery and mentions that the Adco powder required varies from 56 lbs., to 224 lbs., per ton of dry material according to the variety of material used. He gives this analysis:-

Spread of Use

Had the Adco patent been sold to an individualist or dividend-making company with enough capital to thoroughly advertise and exploit its use, it is probable that the demand by this time would be very much greater than it is. On the other hand the profits demanded by shareholders and the possible antagonism of fertilizer combines or a successful negotiation for a 'merger' with them might have worked otherwise. As matters stand, the use of Adco shows a growth steady, but surely based solely on the merits of the discovery. The low cost of manure production and the simplicity of the procedure appeal even to the practical English farmer usually suspicious of any agricultural innovation. In the U.S.A. where a great increase in use is reported, the Adco method is adopted mostly by professional and home gardeners and truck growers. The objective of Rothamsted, the utilization of straw, is as yet barely thought of in the United States and Canada.

Apart from paragraphs and papers appearing in the Rothamsted Reports and the Journal of the Ministry of Agriculture in Britain since 1918 the Journals circulating among the farming community of North America and elsewhere have contained, as far as can be gathered from the 'Agricultural Index', few notices of this important discovery. As these are cited here merely to illustrate its growth in use, their content as related to the scientific question is mostly omitted. An account of the research involved and its ultimate form as patented will be treated later in full.

1921-22. The Rothamsted Report (p.19) stated that some 2,000 tons of straw, in lots varying up to 80 tons had been treated on different farms. The material had been considerably improved by the introduction of phosphates, but difficulties remained connected with the wetting of the straw. The product was not yet up to a good sample of true farmyard manure, but was being steadily improved and the 1922 results

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The chemical compound and process for converting cellulose material into manure was patented by Rothamsted (English patent No. 152,387) to protect the public and was registered as A.D.Co.; the Agricultural Development Company was formed to extend its use.

The list given below of material that has proved suitable for conversion in different countries is a guarantee of a world-wide adoption of the process in time.

Materials tested with A.D. Co.; analysis compared with dung manure.

Straw (wheat, oat, barley, rice and rice husks) in England, Europe, North America, Australasia, India.

Wild grasses, including wild sunflower and rushes:- England, Uganda, Sweden, Rhodesia, India, Brazil, Malaya.

Garden refuse including bracken and hop bines:- England, North America, New Zealand and other countries.

Maize stalks:- Australia, Rhodesia, Brazil.

Sugar cane trash:- Jamaica, Trinidad, Guadeloupe, Demerara, Mauritius.

Banana and pineapple leaves:- Cape Colony, Central America, Canary Islands.

Willow bark:- England.

Water hyacinth, tea prunings and coffee waste (India); gayula rubber product (Mexico).

| Analysis per 100 parts: | Water | Organic Matter | Nitrogen | Ph.Acid | Potash |
|---|---|---|---|---|---|
| Dung of average quality | 76.1 | 18.9 | 0.53 | 0.23 | 0.56 |
| English Wheat straw by Adco process | 70.1 | 14.97 | 0.64 | 0.45 | 0.20 |
| English Garden refuse by Adco process | 63.7 | 16.3 | 0.55 | 0.94 | 1.25 |
| English Grass cuttings(fresh) by Adco process | 82.7 | 10.1 | 0.85 | 0.62 | 1.02 |

In view of the great variety of the materials that have proved suitable it might be worth a thought whether some of the peat bogs, especially those contiguous to fruit growing districts, might not be utilized, and also whether the abundant crops of weeds on land that has gone out of cultivation might not be used to restore its fertility.

persons desirous of participating in the advantages to be derived from the process may quite fairly be expected to contribute to the cost of development by a reasonable payment either in the nature of a royalty or otherwise.

I am hoping to obtain the co-operation and assistance of those farmers who will benefit by the scientific work, as a result of which this discovery has been made possible.

The royalties now to be fixed will be available, after payment of expenses, to form a fund for further Scientific Research along practical lines in Agriculture, and in view of this I feel sure that no difficulty or objection will arise on the part of the farmers who avail themselves of this discovery to make a reasonably small payment for the right to use it, and to technical advice and assistance in its practical operation.

In view of the number of people who have followed with interest what has so far been done, I think the above information will be useful. Any communications with regard to the facilities afforded by the Company should be addressed to The Agricultural Development Company, 12 Spencer Road, Harpenden, Herts.

Yours faithfully,

The Secretary, (sgd.) Elveden.

Ministry of Agriculture and Fisheries.

In view of the chagrin many have felt after putting trust in much-advertised nostrums, special attention must be paid to the paragraph in Lord Elveden's letter which makes it clear that the net profits of what is now known as A.D.Co. (i.e., Agricultural Development Company) after paying the cost of efficient world-wide distribution will be devoted to agricultural research. Mankind is the only shareholder.

depends and also to the conditions on a particular farm which will secure due economy of labour and material. The Ministry, therefore, advises such enquirers as may be desirous of proceeding further into the matter to put themselves into communication with the Agricultural Development Company which Lord Elveden has established on the public-spirited lines described in the letter printed below:-

15th December, 1921.

Sir,-- For some years past I have been deeply interested in the furtherance of Agricultural Research and have been frequently impressed with the lack of adequate organizations to undertake the development of Research results to the stage of application to practical farming.

In the case of seeds, the National Institute of Agricultural Botany fills the need, but there is no similar organization concerned with fertilizer and soil problems.

I have now decided to form a company called the Agricultural Development Company to fill the gap, in which company I shall provide the capital required in the first instance.

The primary object of the Company will not be to make profits for the benefits of its shareholders, but to try and develop as a business such processes as, for example, that for converting straw into artificial manure, discovered and applied by Dr.H.B. Hutchinson and Mr. E. Hannaford Richards, of Rothamsted.

It has always been my ambition to see whether it is not possible to make certain branches of Scientific Research self-supporting; and since any progress to this end requires employment of a qualified staff and the purchase of mechanical plant,

There seldom was a better example of the value of research. First, two men of science with no thought of particular application discover, isolate and cultivate a microscopic agent. Its peculiar powers are tested and proved. Then other men of science, knowing of a particular need, carry on the work of the pure scientist and apply the discovery to current needs.

Finally we may hope that it will be made available for cultivators the world over and increase the productivity of the soil, threatened by the substitution of oil-power for horse-power.

Nor is this all. The new facts have other applications. This artificial manure will produce a valuable gas, whether for heating or lighting. Quite new methods have been found of recovering nitrogen (much the most valuable of chemicals), that would otherwise be lost, from sewage and some other substances.

There never was a time when the endowment of agricultural research promised such quick and far-reaching returns."

Such a pronouncement brought a crop of letters to the Minister, and the 'endowment as yet insufficient' was soon nobly remedied, as can be seen from the statement published by the Ministry of Agriculture in its Journal for February, 1922:-

"Several enquiries have been addressed to the Ministry by farmers and market gardeners who wished to make a practical trial of the method of converting straw into farmyard manure on the lines of the experimental work carried out at Rothamsted by Dr. Hutchinson and Mr. Richards. Though the principle involved is established and presents no difficulties, the practical application involves much consideration of detail both with regard to attention to particular points on which success on a large scale

was discovered and multiplied at Rothamsted some while ago, It has so flourished that its digestive powers have passed all expectation and it is now capable of taking the place of cattle and horses.

The special work to which it is being harnessed is the "breaking down" of straw. With the help of some other kindly bacteria and bacilli it will convert straw into the best "farmyard manure".

This achievement has been watched for some months in the laboratory with unvarying success. Straw has been converted into the best manure without the aid of any animal big enough to be visible.

The method is now proving equally successful on a large scale. Tons of straw so treated are quickly and cheaply converted into a fertilizer that has all the mechanical as well as the chemical virtue of the ordinary farmyard manure.

The straw is twice watered, then treated with a mild sprinkling of a nitrogenous solution; and the benevolent bacteria go to work at once, multiplying into incalculable millions within a few days.

Farmers who have seen the product are convinced of its value, which indeed has been proved by a number of plot tests. The discovery is timely as the supply of manure has already dwindled much below the demand owing to the extinction of the omnibus horses and other animals.

Straw, now as good as valueless, thus becomes a source of wealth.

The present idea is to equip a travelling apparatus for treating farmers' straw, but as yet endowment is insufficient.

It is not without interest to trace the history of this discovery that saw the light but ten years ago, to note what use of it has been made in various countries and to try to explain in 'the vulgar tongue' the chemical basis on which it rests.

Cause of this Special Research

When the effect of the Great War left Britain with an excessive amount of straw in the stack and a shortage of live-stock to make the much needed barnyard manure, the bio-chemists and bacteriologists at the Rothamsted Experimental Station, founded in 1843 by Sir John Lawes, were called on to discover a method by which plain straw could be converted into manure without the medium of live stock.

Owing to long practice at Rothamsted in handling problems of soil-chemistry and bacteriology and the amount of scientific knowledge accumulated for use on demand, the experts in Fermentation (E.L. Richards, R. L. Amoore) in Bacteriology (H.G. Thornton and P.H.H. Gray) and in Protozoa (D.W. Cutler and Lettice Crump) rapidly accomplished the paradoxical task. In fact it was as early as 1921 that the discovery and some results were decisive enough to admit of publicity. In the Daily Mail of September 1921 the following 'story' appears:-

"A New Farm Wonder"

by Sir William Beach Thomas

"A notable discovery, of especial interest to gardeners and farmers, has just passed out of the laboratory into the practical stage.

A bacillus with such a powerful digestion that it can "break down" cellulose -- the toughest part of vegetable growth--

over timber-cut lands, and may vastly increase the yield of garden and field. The purpose of manuring is to feed and further the increase of the micro-organisms which break down the organic matter in the soil and convert it into useful plant food.

Recent elaboration of counting methods at Rothamsted have made it possible to take a census of this soil population showing 45,000,000 bacteria in a gram of soil in a spring period of high activity and half the number in winter. It is a blessing that the food requirement of this soil population bears a ratio to their invisibility rather than to their numbers.

The important fact to bear in mind is that they must be fed. Wheat has been grown on plots in the Broadbank field at Rothamsted every year since 1852.

The average yearly yield per acre for 71 years was thus:-

| Treatment of Plot | Yield of Dressed Grain | Yield of Straw |
|---|---|---|
| No manure | 12.1 bushels | 9.9 cwt. |
| Complete mineral fertilizers | 13.9 " | 11.7 " |
| Farmyard manure only | 34.3 " | 34.6 " |

Owing to humus supplied by farmyard manure (and also by synthetic manure) the only plot out of 18, of which 16 were supplied with standard mineral fertilizers, showing no deterioration whatever is that which has been treated with farmyard manure alone.

The mean yield of wheat per acre in various countries for 1901-1910 was:

| | | |
|---|---|---|
| Denmark | - | 41.3 bushels |
| Belgium | - | 35.1 " |
| England | - | 31.7 " |
| Germany | - | 29.1 " |
| Canada | - | 19.5 " |
| U.S.A. | - | 14.3 " |

The 10 year average for Canada 1916-25 was 15.2 bushels.

## Preface

Imagination, however tightly bridled, cannot fail to estimate the bearing on the food supply of the world of the Rothamsted discovery summed up in the title of this paper. Experience of the process in England and still more in other parts of the world has proved it to be practical and economical and to present no serious difficulty.

Organic humus-giving manure identical with the product of animal excretion is now available to the man who grows any vegetable crop on a part of an acre or on thousands.

The small scale farmer, truck grower or gardener may now at trifling cost increase the amount of his produce and the richness of his soil, quite apart from any increase or richness due to manure from his horses,cows, sheep or pigs, and in fact without either keeping any live stock or expenditure on chemical fertilizer, except where advisable for a particular crop.

Far more important should be the ultimate effect of this discovery on agricultural economics.

In time to come the immense amount of straw now discarded as unusable in Canada and other countries growing cereal crops on a vast scale will be used to renew the soil where it shows signs of exhaustion and maintain for all time the fertility of rich soils that except to the soil chemist appear "inexhaustible".

The waste ammonia liquor, the sewage that corrupts many rivers, or a dilute solution of cyanamide can be brought into contact not only with waste straw but with the weeds that encumber road sides and boundary fences or with the green trash that grows

## SYNOPSIS


Page

1. Preface - Value of the Discovery.

3. Why, Where and How this Special Research was Undertaken

3. Sept. 1921 - Letter of Sir William Beach Thomas.

6. Feb. 1922 - Letter of Lord Elveden.

8. The Agricultural Development Company.

8. Materials Treated in Various Countries.

9. Spread of Use 1918-1926 as gathered from Various Publications.

16. Steps by Which Rothamsted Arrived at the Discovery.

18. Large Scale Work.

19. Synthetic Manure and Farmyard Manure Compared.

21. Patent No. 152,387 (English)

22. Explanation of terms used in the Patent;
A Summary of the Process.

Conversion of Straw or any other Cellulosic Vegetable Waste into Manure identical in chemical and physical properties with Farmyard Manure.

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